

SOUTHWEST FISHERIES CENTER ADMINISTRATIVE

REPORTS, 1974

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SUMMARY OF JAPANESE SKIPJACK TUNA FISHING ACTIVITIES
IN THE PACIFIC, 1973¹

After it became apparent that the larger tunas, the bluefin, bigeye, yellowfin, and albacore, were being harvested at about the maximum level, and that no great increase in yield could be expected from these species, the Japanese turned to alternate resources, mainly the skipjack tuna. The Japanese Fisheries Agency announced a policy of skipjack tuna development, based on estimates of potential annual yield of up to a million tons of skipjack tuna in the Pacific. This resulted in what some Japanese refer to as the "skipjack boom" in Japan. New and larger skipjack tuna vessels, some as large as 500 tons, began to enter the skipjack tuna fishery, and there was a definite move to increase the skipjack tuna fleet while decreasing the tonnages in the longline fleet. This skipjack boom resulted in a sharp divergence in views among Japanese scientists. Some began to warn the government that the skipjack tuna resource would not be able to withstand uncontrolled expansion (Kasahara, 1971 and Kawasaki, 1972). They indicated that the coastal water fishery was already being affected by heavy fishing in the Japanese southern water fishery (extending from the Bonin south to the equator and including such areas as the Caroline, Mariana, and Marshall Islands). They pointed out that the southern fishery was being heavily fished and data from certain "heavy effort" areas already showed declining catch rates. The others submitted, on the other hand, that the skipjack tuna potential was indeed great, and that the landings could be substantially increased by developing new fisheries in various offshore areas not now fished. Basically, no serious differences exist today. The latter group of scientists concede that great effort should not go into fishing either the Japanese coastal skipjack tuna or the present southern water skipjack tuna, although they insist that the skipjack tuna fishery can be greatly expanded by developing new fishing grounds. This latter view is well expressed in a recent conference talk by Akira Suda (1972) of the Far Seas Fisheries Research Laboratory.

THE JAPANESE SOUTHERN WATER FISHERY

The southern water fishery (Tohoku Regional Fisheries Research Laboratory, n.d.) began after World War II but became of significant proportions in the early 1960's. It developed after the Japanese found that the skipjack tuna resource in Japanese coastal waters was nearing the limit of exploitation, and that the resource in southern waters could be exploited during the off-season in Japanese coastal waters. In general, the vessels fish the southern waters, which extend from the Bonins and Marianas down to the Caroline and Marshall Islands in the western Pacific, from fall to spring and the Japanese coastal waters from spring to fall. The best fishing in southern waters appears to be around January-February, as opposed to the summer months in coastal waters.

¹Prepared by Southwest Fisheries Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Honolulu, Hawaii 96812, for meeting of the Skipjack Tuna Expert Committee on Fisheries, South Pacific Commission, February 25-March 1, 1974.

Live bait is the big problem in this fishery. Presently, the vessels load anchovies obtained from bait stations in southern Japan before they head for the distant southern grounds. A 190-ton vessel carries about 370 buckets of bait; a 350-ton vessel about 500 to 600 buckets. The run to the ground takes a week to 10 days or more. The vessels spend about 10 days fishing; thus the total trip takes about a month. Until recently bait mortality was very high, ranging from 30% to 60%. After the vessels leave Japan, the sea surface temperature rises as they run southward, and this rapid temperature change is a major cause of mortality.

Several approaches were studied to reduce bait mortality, such as improving the bait-tank design or refrigerating the bait-tank water. The Japanese now report considerable improvement in transporting bait to the southern fishery merely by taking on "strong" bait at the outset. These are anchovy that have been held in bait compounds for periods of a week to a month, and fed regularly. When such bait are taken, they are better able to withstand considerable changes in temperature. The vessels are now routinely experiencing 70% to 80% survival and the best record is an 85% survival, with bait carried as long as 45 days.

An interesting recent development in this fishery has been the expansion of fishing grounds eastward to the waters of the Marshall Islands and the Gilbert Islands during 1972.

The total landings from southern waters are difficult to determine, but landings at Yaizu port alone, where from 50% to 80% of the southern water fish are landed, they have ranged from 14,020 metric tons in 1964 to a high of 51,286 metric tons in 1971. The landings per vessel (per trip) have ranged from 37.9 metric tons in 1964 to 71.9 metric tons in 1971.

OPERATIONS IN FOREIGN WATERS

Since the range in the operation of home-based skipjack tuna vessels is limited by the problem of live bait, a second approach vigorously pursued by the Japanese is a joint venture operation with a foreign company. The modus operandi in these joint ventures (e.g., Papua New Guinea) has been the employment of mother ships and a fleet of small catcher vessels. Thus far, the catcher vessels have been chartered from Okinawa since Okinawan fishermen are particularly adept at capturing live bait in tropical areas (in prewar years, the Japanese fisheries in the Mandated Islands were prosecuted largely by Okinawan fishermen). The mother ships provide some logistic support to the catcher vessels in addition to receiving the catches for transport back to Japan. This type of operation precludes the need for expensive shoreside facilities during the exploratory phase of the operation.

The reliance on Okinawan fishermen may gradually diminish as the UNDP/FAO Fishing Training Centre in Korea produces more fishermen trained in the skills of skipjack tuna fishing by the pole-and-line method. The entry of Koreans into the skipjack tuna fishery is starting, and apparently, an American company (Del Monte) is placing great faith in the promise that Koreans will soon enter the fishery in great numbers.

Papua New Guinea

Skipjack tuna fishery development is proceeding actively in the Papua New Guinea area under the Australia-Japan fisheries treaty. There are three joint ventures involved: Kavieng in New Ireland, Madang in New Guinea, and Rabaul in New Britain.

The three joint ventures began in 1970, each between a Japanese fishing company and an Australian firm. Each operation involved one or more mother ships from Japan to receive catches made by several catcher vessels chartered from Okinawa.

The 1971 landings from these three joint ventures amounted to around 17,000 tons, all of which were returned to Japan. The 1972 season was poor, perhaps due largely to lower water temperatures that prevailed throughout the western Pacific. The average temperature was 1°-2°C lower (27°-29°C as opposed to the normal 28°-30°C), and strong southeasterly winds also hampered fishing. Although total landings amounted to 13,000 tons, the catch per unit of effort in 1972 was reported to be considerably below the 1971 level. As of November 1972, fishing had greatly improved, and vessels were averaging individual catches of more than 10 tons per day.

There is presently a katsuobushi (dried skipjack tuna stick) processing plant at Kavieng, designed to handle 7 tons of wet fish per day, but the output has been maintained at around 4-5 tons per day. Even though the plant produces an excellent product, the production has been temporarily halted by very low prices in Japan. As soon as the price increases, the plant is prepared to resume operations.

The three Japanese companies and, more recently, the Star Kist Foods, Inc. have signed joint venture agreements. All of the companies are committed to cooperate in establishing a cannery, probably in Madang, probably this year. The plans call for the initial construction of a one-line cannery and a 500-ton capacity cold storage facility.

The British Solomon Islands

The Taiyo Fishing Company of Japan is in the Solomon Islands with mother ships and catcher vessels, and reports are that both bait and skipjack tuna are in ample supply there. In 1972, however, the

fishery did poorly, as did the fisheries in Papua New Guinea. Between June 1971 and May 1972, the total catch was reported at around 6,600 tons. The Taiyo Fishing Company is planning to enlarge operations by setting up cannery and freezer facilities in several locations.

SKIPJACK TUNA SURVEYS IN OTHER AREAS

The Japan Marine Resources Research Center, an agency funded both by government and industry, has been sending chartered skipjack tuna vessels to such areas as Tonga, New Hebrides, and New Caledonia to conduct surveys on the skipjack tuna and live-bait resources. These surveys are arranged with the local governments, and if feasible, the next step will presumably be the initiation of negotiations for joint venture operations. In conjunction with these surveys, the Center dispatched a team of three men about 2 years ago to visit the various areas. They returned to Japan with the report that all those island areas are showing growing awareness of their fishery resources and want to develop these resources to their best advantage. The team members stressed that any joint ventures entered into by Japanese companies must of necessity be of equal benefit to the local governments. Obviously, the Japanese are looking not only to Tonga, New Hebrides, and New Caledonia as possible areas of skipjack tuna development, but also to Fiji, Western Samoa, Gilbert Islands, and the islands of the U.S. Trust Territory of the Pacific and possibly others. During the summer of 1972 a few vessels moved as far eastward as the vicinity of the Hawaiian Leeward Islands in response to some scouting reports from longline vessels. Whether this area will be revisited will depend largely on the fishing condition in Japanese coastal waters. In any case, it is obvious that the Japanese are looking to new areas to exploit the skipjack tuna.

PURSE SEINING FOR SKIPJACK TUNA

As indicated by Suda (1972) the market for skipjack tuna is still rather sluggish in Japan. The one hope held for the species is that it would in the future compete with other tunas in the high-priced sashimi market. Since the Japanese feel that this is the optimum utilization of skipjack tuna in the future, they look to pole-and-line fishing as the method for harvesting fish for this purpose. This point, clearly expressed by Suda, emphasizes a major difference between Japanese and American industry goals. On the other hand, the Japanese are not sitting back as far as development of purse seine technology in tropical waters is concerned.

The Japanese Fisheries Agency chartered two purse seiners, the Tokiwa Maru No. 58 and the Taikei Maru No. 23 to conduct purse seine experiments in the waters near New Guinea. The purse seine experiments met with mixed success, as shown in the [Japan.] Fisheries Agency's (1971)

report. This government charter ended when the Japan Marine Resources Research Center was formed, and the latter is now continuing this work.

Between October 1970 and March 1971 the two chartered seiners fished in tropical waters between the equator and lat. 9°N in the western Pacific. There were catches of up to 18 tons of skipjack tuna in a single set, but most of the catches were much smaller. In general, it was concluded that skipjack tuna can be seined in tropical waters, under certain conditions. "Seinable" schools are those found with floating logs. It was also concluded that chances for success would be greatly increased if the sets were made at dawn or dusk rather than during midday.

LITERATURE CITED

[Japan.] Fisheries Agency.

1971. Results of experimental purse seining by Japanese Government chartered vessels, Taikei Maru No. 23 (210 tons) and Tokiwa Maru No. 58 (358 tons). In Report on experimental purse seining, 325 p. (Translated and extracted from Japanese by Tamio Otsu, Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812, 1973, 2 p.)

Kasahara, Kohei.

1971. Skipjack tuna resource and fishing grounds (Katsuo gyojyō to sono shigen). Suisan Sekai 20(10):30-37. (Engl. transl. 1972, 20 p.; available at Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Kawasaki, Tsuyoshi.

1972. The skipjack tuna resource (Katsuo no shigen ni tsuite). The Fishing and Food Industry Weekly (Suisan Shūhō) 660:32-38. (Engl. transl. 1972, 15 p.; available at Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Suda, Akira.

1972. The skipjack fishery of the future (Shōrai no katsuo gyogyō). Kansai Shibu Gyosen Kenkyukai, Mie Chiku Kenkyukai. [Reprinted from Gyosen 182, December 1972, p. 44-52. (Engl. transl. 1973, 16 p.; available at Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Tohoku Regional Fisheries Research Laboratory.

- n.d. Atlas of skipjack tuna fishing grounds in southern waters, 1970-71 fishing seasons. [Two pages text, 30 charts.] (Engl. transl. 1972, 36 p.; available at Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)



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BAITFISH-TRANSPORT PROJECT--A PROGRESS REPORT

10 January 1974

The annual landings of the Hawaiian fishery for skipjack tuna, Katsuwonus pelamis, which average in excess of \$2 million in ex-vessel value, experience considerable fluctuations from year to year. The annual landings fluctuate between 5 and 16 million pounds and average around 9 million pounds. One of the important causes in the fluctuation of the landings is the shortage of live bait. The seasonal availability of nehu, Stolephorus purpureus, the most important native baitfish, varies greatly, but in general, the supply is insufficient to allow maximum fishing effort by the existing fleet. The shortage of bait is particularly acute during the peak skipjack tuna fishing season, from around May to September, when many of the boats spend considerable time searching for and catching bait needed to fish skipjack tuna.

A solution to the baitfish problem which would replace time spent catching bait with additional fishing time could increase the annual catch by as much as 66% and provide for an increase in ex-vessel value of the catch of \$1.9 million. Various solutions have been proposed and researched in the past. The culture of live bait has been tried and to date the results have shown the baitfish to be either too expensive or the cultured baitfish has been unacceptable to the fishermen. Another approach has been the development of artificial bait, e.g., various types of odor-impregnated food pellets. All of these were found to be ineffective.

One of the most direct and feasible approaches to the problem is to bring in a supply of baitfish from areas where they are readily available. In Hawaii's situation, the northern anchovy, Engraulis mordax, from California seems a good possibility. The northern anchovy has been transported to Hawaii in the past on several occasions, mostly on an opportunistic basis and in small quantities. All indications are that this species is hardier than the nehu and would allow the Hawaiian tuna boats to range farther from base port than is now possible with the nehu. Further, the northern anchovy has been used successfully in fishing for skipjack tuna in the central Pacific and it is one of the principal baitfishes used by the tuna bait boats in the eastern Pacific. Consequently, a program was conceived to develop the technology needed for the transportation, holding and ancillary requirements to the successful importation of live northern anchovy from California to Hawaii.

Briefly, the program will be executed in four phases. Phase 1 will encompass a preliminary review and assessment of various baitfish transport alternatives. Phase 2 will test the feasibility of transporting live bait using the alternative assessed to be most promising. Phase 3 will involve the development of a full-scale system of economically transporting bait to Hawaii on a sustaining basis--a system that would supply all of the baitfish needs of the Hawaiian fleet. Phase 4 will comprise report writing.

Phase 1 of the program has already been completed. In this phase, entitled the preliminary baitfish engineering study (moving baitfish from California to Hawaii), several alternative methods of transporting bait from California to Hawaii were considered. This study indicated that the most feasible method of transporting live baitfish would be the development of a bait-tank truck with a self-contained life support system. This system takes advantage of the recently developed roll-on-roll-off system of cargo handling instituted by the Matson Navigation Company on their new vessel, the Lurline. Although this system of moving live bait will still require the solution of many problems, it was concluded that this was the most promising method among the various alternatives considered.

Laboratory personnel are now actively engaged in Phase 2, which will test the feasibility of the bait-tank truck and roll-on-roll-off freighting system. A Navy surplus aircraft refueling tank with a capacity of 5,000 gallons was selected for the prototype that will be developed. During the latter part of the year (1973) detailed plans were developed for the life support system of the bait transportation tank. Plans for the life support system include the installation of a high capacity water pump, aerators, and an oxygen monitoring apparatus. Simultaneously, work has been progressing on the conversion of the interior of the fuel tank to make it more compatible with bait carrying requirements. The interior of the tank is being thoroughly cleaned and coated with a non-toxic resin so that there will be no residual toxic material. As matters now stand, it is anticipated that the life support module will be assembled and installed and ready for testing by February 1974. The life support system will be tested by experimentally holding and hauling threadfin shad, Dorosoma petenense, caught at Wahiawa Reservoir in mid-February. Hopefully, the tank will be shipped to California in late February and a trial shipment of northern anchovy be made in March.

In addition to the work required to develop the prototype bait transportation tank, various people were involved in other related activities. In California, arrangements and details are being worked out for the purchase of northern anchovy from established bait dealers. Bait dealers in Los Angeles Harbor and San Diego were contacted for preliminary discussions. Officials of the California Department of Fish and Game were also contacted. There apparently are no legal barriers to any part of the proposed operations as far as the State of California is

concerned. Discussions with officials of Matson Navigation Company in California and Hawaii have indicated that it will be feasible to utilize the roll-on-roll-off system of the Lurline to transport the tank between California and Hawaii. Agreement on details on freight rates and shipping conditions between our Laboratory and Matson Navigation Company is close at hand.

Experiments were conducted at the La Jolla Laboratory of the Southwest Fisheries Center on the oxygen requirements of northern anchovy. This information was of vital importance to the development of the life support system for anchovy transport. The experiments were to determine the oxygen consumption of northern anchovy at temperatures comparable to what might be expected during the crossing from California to Hawaii, i.e., at temperatures of 15°-16°C and up to 28°C. The results of these experiments generally corroborated what we expected relative to anchovy respiration at the various temperatures. At 15°C, oxygen consumption averaged 0.322 ml/g/h. This was higher than anticipated, probably due to high activity rates at the outset of the experiment. At 27°C the consumption was 0.532/ml/g/h. Thus, water and oxygen requirements are about what we had anticipated. In an open system, 200 buckets of anchovy will require a minimum of 368 gallons of water per minute at 27°C to survive.

A systematic sampling of water to monitor oxygen level, salinity, and temperature in several locations in Keehi Lagoon, Honolulu Harbor, and Kewalo Basin has been underway for about 2 months. These data will help determine the best locations to install our baitfish holding facilities once the full-scale program is underway.

Finally, although it is believed that this program will have no adverse impact on the environment, a "discussion paper" on the possible environmental impact of importing northern anchovy into Hawaii was prepared. Briefly, the accumulated knowledge on the biology of the northern anchovy suggests that this species will not become established in Hawaiian waters. Temperature and habitat requirements of the northern anchovy are not found in Hawaiian waters, thus making it unlikely that a reproducing population of northern anchovies will become established in Hawaii.

NMFS ANNUAL REPORT, 1973

The mission of the Southwest Fisheries Center's Honolulu Laboratory, located in the central Pacific, is to provide U.S. commercial and recreational fishing interests with information about and assistance in the management and development of the fishery resources of U.S. concern in the central and western Pacific Ocean, particularly the development of the skipjack tuna fishery.

Since these objectives require an understanding of the resources, efforts of the Honolulu Laboratory are also directed to such facets of fishery management and development as the assessment of commercial and game fish stocks and the development of bait resources, and to investigations of the relation of fishes to tropical oceanic and island environments. Because of its unique capability to maintain live tropical pelagic fishes, a major effort at the Honolulu Laboratory is a study of the sensory and physiological reactions of tunas and tuna-like fishes to their physical environment.

Accomplishments of the Honolulu Laboratory for 1973 include:

- o Completion of a study of the behavior of skipjack tuna schools in Hawaiian waters, with observations made in June-August 1967 and 1968. Also completed was the analysis of a study that assesses the relative stock density of skipjack tuna in the Hawaiian pole-and-line fishery.

- o Determination that the concentration of mercury in both red and white muscle of newly-caught skipjack which were starved from 20 to 35 days increased at about the same rate as in skipjack fed whitebait containing 0.06 ppm Hg for the same period of time.

o A resource assessment survey was conducted in the Leeward Islands portion of the Hawaiian Islands. Cruise objectives accomplished were the assessment and tagging of skipjack tuna, and the determination of the availability of baitfish species in selected island areas.

o Progress in a study to determine if the fine lamellae observed in the otoliths of the nehu (Stolephorus purpureus), the primary baitfish used in the Hawaiian skipjack tuna fishery, represent daily growth rings. Eight subsamples from three experiments have been read and appear to confirm that daily growth lamellae are formed in nehu otoliths. Mean circuli counts for the time intervals studied closely approximate the expected counts.

Barkley, Richard A.

1973. The Kuroshio current. In R. Gordon Pirie (editor), *Oceanography: Contemporary readings in ocean sciences*, p. 108-118. Oxford Univ. Press, N.Y. (Lond., Toronto). [Reprinted from *Sci. J. (Lond.)* 6(3):54-60, 1970.]

National Marine Fisheries Service
Southwest Fisheries Center
Honolulu Laboratory
Honolulu, HI 96812

DeWreede, Robert E., and Everett C. Jones.

1973. New records of Sargassum hawaiiensis Doty and Newhouse (Sargassaceae, Phaeophyta), a deep water species. *Phycologia* 12(1/2):59-62.

- National Marine Fisheries Service
Southwest Fisheries Center
Honolulu Laboratory
Honolulu, HI 96812

Dizon, Andrew E., Ross M. Horrall, and Arthur D. Hasler.

1973. Long-term olfactory "memory" in coho salmon, Oncorhynchus kisutch. *Fish. Bull., U.S.* 71: 315-317.

National Marine Fisheries Service
Southwest Fisheries Center
Honolulu Laboratory
Honolulu, HI 96812

Dizon, Andrew E., Ross M. Horrall, and Arthur D. Hasler.
1973. Olfactory electroencephalographic responses
of homing salmon, Oncorhynchus kisutch, to water
conditioned by conspecifics. Fish. Bull., U.S.
71:893-896.

National Marine Fisheries Service
Southwest Fisheries Center
Honolulu Laboratory
Honolulu, HI 96812

Hester, Frank J., and Tamio Otsu.
1973. A review of the literature on the develop-
ment of skipjack tuna fisheries in the central
and western Pacific Ocean. U.S. Dep. Commer.,
NOAA Tech. Rep. NMFS SSRF-661, 13 p.

National Marine Fisheries Service
Southwest Fisheries Center
Honolulu Laboratory
Honolulu, HI 96812

Hida, Thomas S.
1973. Food of tunas and dolphins (Pisces:
Scombridae and Coryphaenidae) with emphasis on
the distribution and biology of their prey
Stolephorus buccaneeri (Engraulidae). Fish.
Bull., U.S. 71:135-143.

National Marine Fisheries Service
Southwest Fisheries Center
Honolulu Laboratory
Honolulu, HI 96812

Magnuson, John J.

1973. Comparative study of adaptations for continuous swimming and hydrostatic equilibrium of scombroid and xiphoïd fishes. Fish. Bull., U.S. 71:337-356.

• National Marine Fisheries Service
Southwest Fisheries Center
Honolulu Laboratory
Honolulu, HI 96812

Naughton, John J.

1973. Investigations of billfish biology at the Hawaiian International Billfish Tournament. Mar. Fish. Rev. 35(8):19-25. (Also MFR Paper 997.)

National Marine Fisheries Service
Southwest Fisheries Center
Honolulu Laboratory
• Honolulu, HI 96812

Struhsaker, Paul.

1973. Argyripnus brocki, a new species of stomiatoid fish from Hawaii, with observations on A. ephippiatus and A. iridescens. Fish. Bull., U.S. 71:827-836.

• National Marine Fisheries Service
Southwest Fisheries Center
Honolulu Laboratory
Honolulu, HI 96812

Uchida, R. N., and R. F. Sumida.

1973. Tuna: Pole-and-line fishing trials in
central and western Pacific. Mar. Fish. Rev.
35(1-2):31-41. (Also reprint 962.)

National Marine Fisheries Service
Southwest Fisheries Center
Honolulu Laboratory
Honolulu, HI 96812

Yoshida, Howard O.

1973. Taractes rubescens and Taractichthys
steindachneri from Hawaiian waters. Fish. Bull.,
U.S. 71:900-902.

National Marine Fisheries Service
Southwest Fisheries Center
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January 31, 1974

F14 Center Director, SWFC La Jolla

Attn: David Mackett

F142 Director, Honolulu Laboratory, SWFC, Honolulu

Contacts with constituents, 1973

The enclosed report summarizes the Honolulu Laboratory's activities as they relate to direct contact with our constituency.

Enclosure

MLG:ey

cc: Godfrey

HL
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SOUTHWEST FISHERIES CENTER HONOLULU LABORATORY

Contact with Constituents

A. Industry; Commercial Fishermen

1. The pole-and-line fleet at Kewalo Basin, Oahu, on learning of NMFS Honolulu Laboratory's (HL) need for live tuna for experimental purposes, donated 150 live tunas to us. This resulted in a good feeling among the fishermen for having contributed to our research.
2. HL provides continuing timely information on developments in the Japanese tuna fishery by way of translations of news items and articles in Japanese periodicals. Responses indicate that this service is greatly appreciated. This is actually a "by-product" since the translations are primarily for HL's information bank on tuna resources, Pacific and Indian Oceans.
3. HL provided a guided tour of the fish market and introduction to local fish dealers to owner of Gasparilla Fisheries, Placida, Florida. Constituent sent a memo of appreciation to the Laboratory Director.
4. HL provided a written review of the Laboratory history and accomplishments to the new member of Marine Fisheries Advisory Committee from Hawaii.
5. Local and mainland representatives of the fishing industry were given information on request concerning the demersal resources of the Hawaiian Islands. This included help to a local fish broker on product care and use of common names in marketing.
6. As the result of a paper by Struhsaker and Aasted on shrimp trapping, presented to the South Pacific Commission Sixth Technical Meeting on Fisheries in Fiji, several letters of inquiry were received from Fiji and the Solomon Islands. Information was also provided colleagues at Guam who are presently conducting shrimp trapping experiments similar to those run in Hawaii by NMFS.
7. HL provided the late S. McLeod and T. McCarthy, Hawaiian Tuna Packers (Bumble Bee Seafoods, Inc.), with basic information on the state of the South Pacific albacore stock on two different occasions in November 1973.

8. HL arranged with the captain of skipjack fishing sampan Lehua to carry Mr. James Schones (Sea Grant advisor from Oregon State University) aboard as observer of baiting operations. Also arranged for Mr. Schones to familiarize himself with construction details of a "night" net used in night baiting operations.
9. HL arranged with skipjack fishing boat Anela to have Mr. Robert Stone, fishery biologist from Fiji, aboard for 2 days of observing. Introduced Mr. Stone to officials of United Fishing Agency and Hawaiian Tuna Packers.
10. The Director's Office maintains close contact--by correspondence, telephone, and meetings--with various elements of the producing and processing segments of the commercial fishing industry. The Laboratory Director met with Hawaiian Tuna Packers management (S. McLeod and the present manager Jay Puffinburger) on four specific occasions in 1973. Additional contacts occurred as part of other meetings. Topic of principal concern was the baitfish problem faced by the Hawaiian tuna fishery. The baitfish problem is also foremost with the Tuna Boat Owner's Association; on two occasions the Director met with officials of the association. The Laboratory is progressing in its work on transport of the northern anchovy from California to Hawaii.

The Laboratory Director also met four times with Frank Goto, Manager of United Fishing Agency and currently a member of MAFAC. Topics of concern to Mr. Goto included the deactivation of RV Townsend Cromwell, Laboratory budget cuts, and the Hawaiian baitfish problem.

The Laboratory Director instituted a series of baitfish meetings to discuss our activities in moving anchovy from California to Hawaii. One meeting was held in 1973. Progress with this project is transmitted by progress reports (two to date). Participants in the meeting included industry (producers and processors), University of Hawaii, Sea Grant, Hawaii State Fish and Game, and PIDC.

11. An HL staff member identified samples of baitfish sent from Fiji by the FAO fishery representative there. These identifications contributed to the completion of a basic survey of the fisheries there. The survey is preliminary to the possible development of a pole-and-line skipjack fishery in Fiji.

B. Universities, Community Colleges, and the Scientific Community

1. The Laboratory Director participated in four meetings of the Sea Grant Advisory Committee. He met with Dr. Bardach, Director of Hawaii Institute of Marine Biology (HIMB), on five occasions--meetings intended to keep each other informed of activities in their respective research organizations. He attended two meetings of the Advisory Committee for Marine Programs of the Leeward Community College, providing input on current needs in research for technicians.
2. HL supplied Dr. John Miller, HIMB, with baitfish catch and effort data; discussed baiting catch and effort in Kaneohe Bay, Oahu with two of his graduate students.
3. Assisted University of Hawaii graduate student in economics in a feasibility study he was conducting for HL by providing extensive discussion on baitfish. The study resulted in a report "Estimation of demand for live bait to be used in the skipjack fishing industry."
4. Presented a seminar on acoustic tracking of marine animals to a group of students, UH, March 1973. Provided advice and information on acoustic tracking to UH graduate student and Dr. J. Sylvester of Oceanic Institute, September 1973.
5. Contact was maintained with the scientific community with regard to biological specimens and data collected by HL. Scientist who reported this reported 25 letters written and 250 contact hours provided in a general exchange of information and discussion of mutual problems. He also arranged for a series of informal seminars given at HL and open to all interested persons.
6. Staff oceanographer reports attendance at monthly faculty meetings of UH Dept. of Oceanography; also perhaps a half dozen UH requests for our services, all of which were fulfilled. He also reported nine direct personal requests for information, some requiring considerable "digging" to provide, and six letters asking for information ranging from the trivial to the complex. Five of the six requests were satisfied; one was referred to UH.
7. Life Studies--Tuna reports contacts with UH faculty members and various graduate students to advise on research methods in area of fish behavior and physiology.
8. Made arrangements for our May 1974 participation in Makahiki Kai, a Sea Grant-sponsored "educational experience" for elementary and secondary school students.

Also A.2, A.6, and A.8.

C. Recreational Fishing Interests

1. HL participated in the 15th Annual Hawaiian International Billfish Tournament (HIBT), as staff members organized and conducted a 1-day billfish workshop. HL scientists also collected routine catch and effort data and analyzed stomach contents of billfishes landed during the tournament. The Laboratory Director met several times with Mr. Peter Fithian, one of the principal spokesmen for the billfishermen in Hawaii.
2. XBT recorders were installed on two charter boats in Kailua-Kona, Hawaii. The data gathered will contribute to HL's fledgling Recreational Fisheries study. The result of the installation was an opening up of two-way rapport and a feeling of mutual benefit.
3. HL staff member attended a public meeting of the Board of Governors of HIBT, where he met some of the people more involved in recreational fishing and explained to them our study plans. He also contacted--in person--11 of the 25 charter boat skippers fishing out of Kailua-Kona, explaining our goals and soliciting participation in helping us collect data. He met with leaders of the Kona Mauka Trollers, the largest sport fishing club on the island of Hawaii, to open lines of communication.

D. Hawaii State Government

1. As a member of a committee to update "Hawaii and the Sea, 1969," the Laboratory Director participated in about 12 meetings of the committee of specialists appointed to the task.
2. As a member of the Advisory Subcommittee of Invertebrates and Aquatic Biota, the Laboratory Director participated in one meeting of the group during 1973. During the year he provided advice to the State on requests to import exotic animals.

E. Pacific Islands Development Commission

1. Dr. F. Hester attended the annual meeting of PIDC held in American Samoa in February. On several other occasions meetings were held with A. Gerakas, Executive Secretary, PIDC, to discuss NMFS activities of interest to them.

F. General

1. Two HL scientists reported participation as judges in the science fairs held at local intermediate and high schools in connection with the 16th Annual Science and Engineering Fair.
2. A head count of visitors to the Honolulu Laboratory in 1973, primarily those received in the Director's Office, totaled 88. These visitors represent all aspects of constituency. They come for the most part to discuss the work of our Laboratory, often in relation to their own work, and many are provided with our reports and publications as their needs require.

January 31, 1974

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

***Southwest Fisheries Center
Honolulu Laboratory . . . a background document***



A REVIEW OF THE HONOLULU LABORATORY - ITS HISTORY AND ACCOMPLISHMENTS, AND ITS IMMEDIATE PLANS

Background

The Honolulu Laboratory (HL) of the Southwest Fisheries Center traces its inception to Public Law 329 of the 80th Congress (1947). This Public Law authorized the exploration, investigation, and development of high-seas fisheries of the territories and island possessions of the United States in the tropical and subtropical Pacific Ocean and intervening seas. Funds for the laboratory became available in July 1948, and in 1949 under the capable direction of the late Dr. O. E. Sette the Pacific Oceanic Fishery Investigations (POFI), as it was known then, sent out its first research ships. By mid-1950, when POFI moved into its newly completed permanent laboratory building, a vigorous research program was already underway.

From an administrative perspective, HL has gone through several major changes in its 25 years of existence. Figure 1 summarizes these changes (shown on a time scale). They include reorganizations, changes in directors, changes in objectives, and changes in funding--as indicated by the number of personnel and ships in operation. Appropriations for HL have waxed and waned over the years, reflecting national priorities as perceived by the Executive branch of our government. At present, appropriations are lower than they have ever been--a fact of great concern to HL.

Scientific Activity

Until the 1970 reorganization creating NOAA, the research directions of HL were guided by the Tuna Industry Advisory Committee. The interaction between HL and this committee resulted in extensive, systematic explorations in the Pacific Ocean from the Aleutian Islands to New Caledonia, and from the American Continent to Palau in the Western Caroline Islands. The scientific history of the laboratory is marked with milestones of significant achievement. Some of the highlights of these follow.

- 1 The discovery and delineation of the easterly flowing Equatorial Undercurrent. This current, known as the Cromwell Current, has a flux of 400 trillion gallons per hour, 1,000 times as great as the Mississippi River. Its discovery solved one of the major oceanographic puzzles of our time, the great imbalance of the amount of water flowing westward in the Pacific Ocean as compared to the amount flowing to the east.

HONOLULU LABORATORY

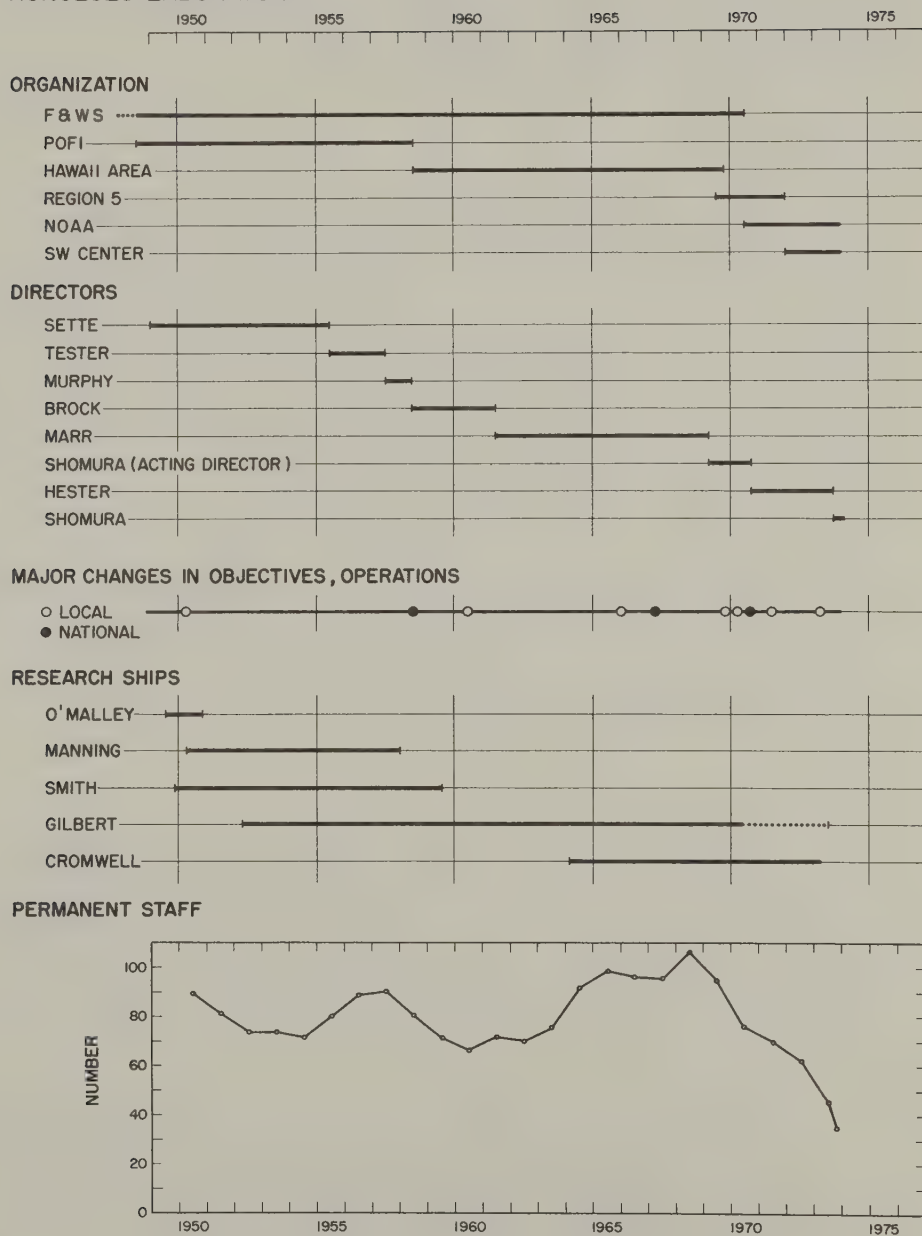


Figure 1

- 2 The location of a concentration of large tunas in an equatorial band and its relationship to the oceanographic and meteorological features of the Pacific Ocean. Owing to economic considerations, American industry failed to take advantage of this resource, but the Japanese did.
- 3 The ability to capture and hold alive for extended periods of time several species of tunas, e.g., skipjack tuna, yellowfin tuna, kawakawa, bigeye tuna, and frigate mackerel. HL was the first research laboratory to succeed in this. Even today, no other facility in the world captures and holds the delicate skipjack tuna. This ability has opened the way for significant experiments on the behavior and physiology of tunas. Items 8, 9, and 10 below are examples.
- 4 A description of the oceanography in the central Pacific Ocean. This description provides basic environmental information of the world of the pelagic fishes, information that is essential to the exploratory and developmental stages of a fishery.
- 5 An oceanographic atlas of the Pacific Ocean.
- 6 Migration models of the albacore and skipjack tuna.
- 7 The identifications and distributions of the larvae and juveniles of yellowfin and skipjack tunas.
- 8 Descriptions of the visual acuity of skipjack tuna and kawakawa.
- 9 A description of the auditory capacity of yellowfin tuna.
- 10 A detailed study of the hydrodynamics of kawakawa and its effect on behavior. Because of major similarities between kawakawa and skipjack tuna, many of the results of this study hold true for the latter species.
- 11 The discovery of potentially valuable shrimp resources in the Hawaiian Islands. The extent of these resources throughout the Hawaiian Archipelago has not yet been defined.
- 12 The ability to tag tunas and other fishes of similar size or larger with electronic transmitters and to track them for detailed studies of their movements and behavior. Although very little tracking of tunas has been done to date, skipjack tuna have been discovered to have remarkable navigational abilities and have been shown to stay close to the surface at night, facts which may be useful to fishing strategy. A short trial of tracking albacore has indicated a close relationship between albacore movements and temperature features in the ocean.

- 13 Predictions of the size of a season's catch in the Hawaiian skipjack tuna fishery. These predictions have been made a half year in advance using temperature and salinity variations monitored at Koko Head on the island of Oahu.
- 14 An understanding of the physics of eddy patterns in the lee of islands. This may some day lead to the ability to predict the distribution and changes in distribution of important commercial species.
- 15 A preliminary description of the subpopulations of skipjack tuna in the Pacific Ocean. This type of study is important for resource management, especially where international considerations are involved.
- 16 Descriptions of the reproductive parameters (capacity, seasons, geographic zones, size at maturity) of skipjack tuna, yellowfin tuna, bigeye tuna, and albacore.
- 17 Estimates of growth rates of four species of tunas: skipjack, yellowfin, bigeye, and albacore.
- 18 An estimate of the potential yield of the skipjack tuna resources in the Pacific Ocean. This is based on a synthesis of known biological information plus estimates of a few unknown factors. The study has led to the conclusion that these resources are quite underutilized, providing impetus for further development of the skipjack tuna fishery. The Laboratory's findings were instrumental in the formation in February 1970 of the Pacific Islands Development Commission, a non-profit corporation consisting of the chief executives of its four member governments: The State of Hawaii, American Samoa, Guam, and the Trust Territory of the Pacific Islands.
- 19 The age determination of local anchovy, nehu, from otolith markings, is significant in that this is the first demonstration that otolith markings can be used to determine the age of tropical fish species. Scale and bone markings have been the most reliable indicator of age in fishes, but these methods have not been effective in tropical areas because they lack marks that can be associated with time.

As may be expected in any research organization, not all endeavors have come to such successful conclusions. Results of other projects ranged from limited success to inconclusive. In this category were early experiments with purse seines, gill nets, substitute bait species, the frequency-modulated sonar, modifications in longline techniques, mass-rearing of baitfish, and artificial bait. However, even the results of these experiments added to our body of knowledge and contributed to a better understanding of the problems.

Over the years of active exploration, HL has accumulated a massive data bank. Much of the data has been analyzed and reported on. The information is by no means depleted, however, and there is still much to be learned by studying data as yet unanalyzed, and analyzing data from a variety of perspectives.

HL activities have included sponsorship of and participation in conferences and meetings of various levels. Through these means a great deal of cooperative research, cooperation, and goodwill have been generated among the countries of the Indo-Pacific complex. It is safe to say that HL has emerged as a leader in fishery and oceanographic research, and commands considerable respect for its accomplishments and experience in the Pacific Ocean.

Plans for the Immediate Future

Fiscal year 1974 was marked by a major budget cut. This resulted in the loss of the research vessels Charles H. Gilbert, decommissioned and put up for public sale, and the Townsend Cromwell, deactivated for an extended period of time. It also forced a severe reduction in manpower and the attendant scientific and technical skills. Eying the possibility of an equally lean FY 1975, it was agreed that a program had to be constructed for HL which would make best use of its existing capabilities and funding. It was decided that the major effort be directed toward the assessment and development of the skipjack tuna resources of the Pacific and Indian Oceans.

Considerations which affected this decision were (1) an increasing demand for tuna products; (2) the realization that of all the world's supplies of tuna, skipjack tuna is the one underutilized tuna resource; and (3) rapidly increasing foreign competition for the existing skipjack tuna.

The long-range benefits of the proposed program--if it leads to even modest levels of fishery expansion or development--are very large in comparison to the costs. From a national point of view increased domestic catches in the central, southern, and western Pacific will:

- o decrease the rate of dependency on foreign-caught fish, thus resulting in a balance of payments that is lower than it might otherwise be;
- o increase the efficiency of capital investment through increased use of vessels, thereby increasing United States productivity;
- o have important considerations in the conduct of international affairs.

The work plan calls for NMFS to perform a portion of the tasks, utilizing staff members of the SWFC Honolulu and La Jolla Laboratories.

Pending full program funding the gear design, construction, and testing and exploratory fishing work may be the responsibility of an independent contractor. The program will coordinate wherever possible with activities of Sea Grant, university, state, and other agencies.

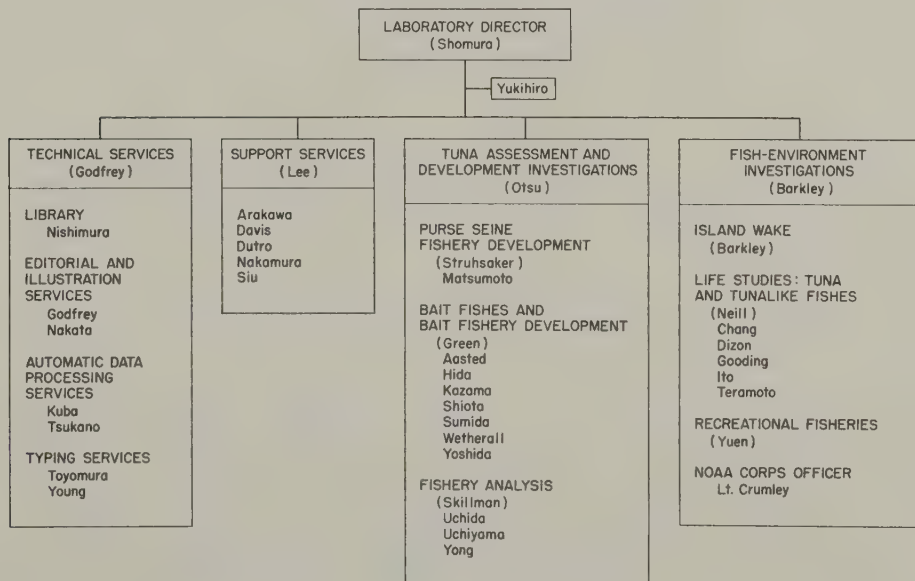
PRESENT ORGANIZATION OF THE HONOLULU LABORATORY

Honolulu Laboratory Structure and Current Programs

HL, under the direction of Richard S. Shomura, is divided into four groups: The Tuna Assessment and Development Investigations (TADI), headed by Tamio Otsu; Fish-Environment Investigations (FEI), under Dr. Richard A. Barkley; Technical Services, headed by Ms. Mary Lynne Godfrey; and Support Services, under the supervision of Edwin K. W. Lee.

Tuna Assessment and Development Investigations is structured to handle the assessment and development of skipjack tuna in the Pacific and Indian Oceans. Fish-Environment Investigations is organized along three separate lines of study. In FY 1974 the Island Wake

HONOLULU LABORATORY ORGANIZATIONAL AND STAFFING CHART



Studies will complete the investigation into the effect of islands on the physical dynamics of the ocean. Life Studies: Tuna and Tunalike Fishes will study the reaction of tunas to the environment and will concentrate initially on skipjack tuna and water temperature. Recreational Fisheries is a small first step by HL to provide much needed research in areas of interest to the sport fishermen. Plans are to study the relationship between the distribution of billfishes and the environment, and to evaluate the status of the fisheries for billfishes.

Following is a Brief Statement of Each of Honolulu Laboratory's Several Programs

MARMAP III: SKIPJACK TUNA, PACIFIC AND INDIAN OCEANS

Principal Investigators: Tamio Otsu, Roger Green, Dr. Paul Struhsaker

The skipjack tuna is an underutilized species with considerable potential for development. The development of skipjack tuna fisheries in the central, southern, and western Pacific is urgent from the point of view of increasing the supply of tuna for the U.S. tuna industry and helping the people of the Pacific Islands expand their economic bases and their employment. In response to these needs, a major effort of the Honolulu Laboratory's research program is the conduct of various studies that will assist in the development of skipjack tuna fisheries.

- 1) A limited supply of skipjack tuna baitfish has impeded the establishment of new tuna fisheries and the growth of existing ones in many areas of the Indo-Pacific. During fiscal year 1974 we will complete a comprehensive background document summarizing what is known of the availability, distribution, and behavior of the various species composing the baitfish resources of the central, southern, and western Pacific, to serve as a basis for further studies of the resource.

We plan to augment the local bait supply of the Hawaiian fishery by transporting the northern anchovy, Engraulis mordax, from California to the Hawaiian Islands. A combination of economic and technical considerations indicates that a transport tank via roll-on/roll-off freighter is presently the most feasible system, and a pilot program has been initiated. A 5,000-gallon aircraft refueling system is being modified and equipped with a life-support system. The first trial shipment of baitfish is planned for March 1974. Final objective will

be to encourage and advise private interests in developing a full-scale, bait-transport program.

- 2) We will utilize domestic and foreign tuna fishing information and statistics to determine optimal fishing strategies for both purse seine and pole-and-line vessels fishing in the Indo-Pacific region.
- 3) The efficiency of harvesting skipjack tuna may be increased through the use of the recent Japanese-developed automatic pole-and-line fishing machine, and/or through the establishment of a workable trolling system for small vessels. In Hawaii, where experienced skipjack tuna fishermen are in short supply, an automatic pole fishing machine will be tested on a local skipjack tuna vessel. To explore the economics of a small-craft trolling system, our Laboratory will first undertake a paper study. If feasible, a system patterned after west coast albacore trolling rigs will be tested during peak fishing months in American Samoa.
- 4) Participation in the Pacific Islands Development Commission's (PIDC) cooperative program for the development of the tuna resources of the central, southern, and western Pacific calls for the preparation of a document containing all previous tuna research and exploratory fishing information, participation in the PIDC-Industry tuna purse-seine development program, and provision of continuing fishery information and intelligence.
- 5) During fiscal years 1975 and 1976 experiments will be conducted in the central Pacific utilizing several types of devices that could attract and aggregate skipjack tuna. An obvious benefit would be a more efficient harvesting of these tuna schools by purse seine and pole-and-line fishing gear.
- 6) Technical knowledge gained through the foregoing activities will be made immediately available to fisheries officials of Pacific Island areas of concern to the United States.

FISHERY ANALYSIS: TUNA MONITORING AND ASSESSMENT,
PACIFIC AND INDIAN OCEANS

Principal Investigator: Dr. Robert A. Skillman

The Southwest Fisheries Center has developed a plan for the exploitation of the skipjack tuna resources of the central and western Pacific. The plan is designed to place major emphasis on stock assessment, fishery monitoring, and various aspects of fishery liaison.

In addition to the development of the skipjack tuna resource, we plan to monitor the status of exploited Pacific stocks of other tuna and tunalike resources of U.S. concern through the systematic collec-

tion and analysis of fisheries data. The stock assessments and production models of other tuna species will aid in resource management and economic planning, and will provide the background needed for international negotiations.

Anticipated accomplishments of the program for fiscal years 1974, 1975, and 1976 are (1) the collection of data from the several tuna fisheries operations in the Pacific Ocean and also in segments of the Indian Ocean. This is to provide the basis for assessments of distribution and abundance, activities which will be kept relevant to industry needs by our continuing liaison with the fishing industry; (2) assessment of skipjack tuna, resulting in current reports on the status of stocks; (3) complete reports on the longline fisheries of the Pacific and Indian Oceans, and "status of stock" reports on the albacore, bigeye tuna, and yellowfin tuna populations of these fisheries.

Increases in funding would open possibilities of the placement of observers on U.S. vessels performing exploratory fishing operations in the western Pacific, and of the tagging of skipjack tuna in the Caroline and Marshall Islands of the western Pacific, enabling us to describe the stock structure on a seasonal basis.

ISLAND WAKE INVESTIGATIONS

Principal Investigator: Dr. Richard A. Barkley

Island Wake Investigations explores the hypothesis that island wakes enhance organic production by causing upwelling into the surface layers of the adjacent waters, and that this increased production and resulting enrichment accounts for the observed increase in availability of scombrids in the vicinity of islands, banks, and seamounts. Since the success of commercial fisheries is often dependent upon aggregations of fishes, the understanding of this association cannot be overlooked. Observations being analyzed were obtained during two cruises of RV Townsend Cromwell to the Line Islands in the central Pacific. Plans call for the synthesis of these results into a self-consistent model of the physical, chemical, and biological structure of the island wake systems observed during the field program. Ensuing quantitative estimates of availability of forage for larval, juvenile, and adult scombrids define the "carrying capacity" of the nearby open ocean. Such a comparison will confirm or disprove our hypothesis that the association of scombrids with islands is quantitatively related to an increase in food supply.

The methods developed during this study will also be applicable to larger scale problems of coastal boundary layer systems where upwelling predominates, and to predictive models based on energetics and food chain dynamics.

SKIPJACK TUNA OCEANOGRAPHY

Principal Investigator: Dr. Richard A. Barkley

The influence of variables in the marine environment on the populations of skipjack tuna needs to be examined. There is considerable information on the abundance, distribution, migration, availability, spawning, growth, food requirements, etc., of skipjack tuna, and even more information about the regions of the ocean which it inhabits. These two sets of knowledge, however, have not been systematically related to each other except in a few special cases or in limited geographic regions. A systematic effort is required to identify the environmental factors which most significantly influence the skipjack tuna's availability and its response as a population to fishing mortality.

This study proposes to analyze available time series data on apparent abundance, distribution, and other population parameters of skipjack tuna critically related to major oceanographic and meteorologic parameters within the habitat range of this species. In this way we hope to determine whether there are significant statistical correlations or clearcut coincidences between significant individual events (e.g., El Niño) in both the fisheries and the environment, either locally or on an ocean-wide basis.

To the extent permitted by the available data, it should be possible to isolate those factors in the environment which significantly correlate with fluctuations in skipjack tuna population parameters and to rank these in order of probable importance.

The framework of the investigation will consist of explicit conceptual models of the energetics and life history of the skipjack tuna, and corresponding conceptual models of the tropical and subtropical ocean and atmosphere, such as Bjerknes' model.

Once assembled, the available data can be related to data from various world skipjack tuna fisheries by statistical correlation, by comparison of unique events, or combinations of events and parameters, with results leading to informed, well-founded predictive models.

LIFE STUDIES: TUNA AND TUNALIKE FISHES

Principal Investigator: Dr. William H. Neill

In the tuna fisheries of the Pacific, the major biological problem is prediction of the distribution and abundance of the resource. While fishery and oceanographic data collected over the years have improved our understanding of fish distribution and environmental conditions, the mechanisms of such distribution and production are unknown and require a concerted effort to measure directly the responses of tunas to environmental factors. This program sets forth a list of achievements and aims for fiscal years 1974, 1975, and 1976 which, by 1976, will have contributed sufficient information to allow

the development of a preliminary model for distribution and production of skipjack tuna in the Pacific Ocean.

The initial modeling effort will center on distributional responses to temperature, particularly temperature preference. Measurements accomplished or planned to contribute to this include those of routine metabolism and lower lethal oxygen concentrations, spontaneous swimming activity as a function of temperature, temperature discrimination thresholds, and the measurement of rates of heat exchange. Experimental animals are both the skipjack tuna and the kawakawa, handled by an experienced research team. Prime beneficiaries of these studies will be the government units charged with management of tuna resources, and the commercial tuna fishing industry.

A major endeavor contributing toward the successful development of the distribution and production model will be the development and construction of an apparatus for measuring preferred temperatures of tunas. A tuna's direction of swimming (clockwise, counterclockwise) in a doughnut-shaped tank will control the direction of temperature change; swimming speed will control rate of temperature change. The preferred temperature of the fish can be determined from the record of tank temperature through time.

Laboratory experiments are to be designed and scheduled to maximize the rate of information growth for the modeling effort.

FY 1979 is the target date for the completion of a predictive model for the distribution and production of skipjack tuna in the Pacific Ocean. The model will simulate time/space changes in skipjack tuna numbers and biomass on the basis of the skipjack tuna's behavioral and physiological responses to the time/space distribution of oceanographic conditions.

RECREATIONAL FISHERIES

Principal Investigator: Heeny S. H. Yuen

Many of the species sought by recreational fishermen in the central and eastern Pacific such as the billfishes (Istiophoridae and Xiphiidae), the dolphin, Coryphaena hippurus, and the wahoo, Acanthocybium solandri, are also taken commercially both intentionally and incidentally. It is unlikely that the saltwater recreational anglers can seriously affect the stocks of the species they seek, but the combined pressure of commercial and sport fisheries most assuredly can.

Among the marine species most important to sport and commercial fishing interests are the billfishes. Ecologically they are similar to the tunas; unlike tunas, they are poorly known biologically. Even less is known of the dolphin and wahoo. All aspects of the biology of these species need to be studied for rational utilization of the resources with consideration given to all user groups.

Research needs include (1) the conduct of life studies research directed toward specific problems of the fisheries; (2) development and maintenance of the data base and data management techniques needed

to manage the resources; (3) conduct of life studies research in direct support of international negotiations.

Research activities to be accomplished during fiscal years 1974, 1975, and 1976 are (1) the analysis of records of Pacific longline fisheries on catch, effort, and distribution; (2) studies of spawning, age determination, and growth; (3) a study of short-term movements of billfishes off the west coast of the island of Hawaii utilizing known tracking techniques, together with (4) the collection of coordinated environmental measurements.

Information on distribution, ecology, yield levels, movements, and biology of billfishes, dolphin, and wahoo in the Indo-Pacific region will be the products of the program. This information will provide a factual base for utilization decisions in the areas of allocation of fishery quotas, resource management, and international negotiations.

The intended primary beneficiary of this program is the sport fisherman. The ultimate benefit, of course, will be the preservation of these species for full utilization by all interests.

ASSESSMENT AND DEVELOPMENT OF INSULAR FISHERY RESOURCES

Principal Investigator: For the current year the input will be provided by the Director's Office; some staff will be borrowed from on-going program personnel.

The objectives of this program are to identify and assess the principal fishery resources of the insular waters of tropical oceans, and to determine their maximum sustainable yield. Successful accomplishment of program objectives will result in optimal utilization of the insular fishery resources by the peoples of Hawaii, American Samoa, Guam, and the Trust Territory of the Pacific Islands. Most of the current protein needs of these people of direct concern to the U.S. as well as millions of other island inhabitants scattered throughout the Pacific Ocean are being met by imports of non-fishery products. The seas, especially the outer reef zones, are capable of providing much more protein. There is a need, however, to survey and assess these insular resources for optimal utilization by the island communities.

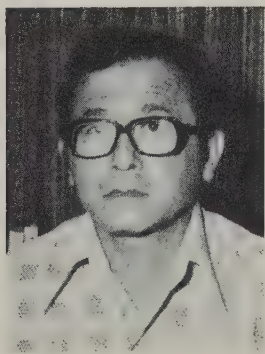
This program at present is in the "preliminary planning" stage. Approval of the proposal will lead first to the development of a "prospectus" by the staff of the Honolulu Laboratory, a document that will provide the rationale and background for the program. This document will be completed by the end of fiscal year 1974 and be followed by a detailed presentation of the full-scale program. Field work will begin with a preliminary assessment of the insular resources of the Leeward Island chain of the Hawaiian Archipelago, highly desirable because it is an area of essentially virgin conditions and also because of its proximity to Honolulu.

Since the scope of research envisioned for this study goes beyond the present capabilities of the Honolulu Laboratory, the presentation

will include contributions of interested research groups. The State of Hawaii in a recent updating of Hawaii and the Sea, 1969 reconfirmed the priority need to survey and assess the marine fishery resources of the Leeward Islands. Preliminary contacts have been made with representatives of the Hawaii State Division of Fish and Game and the University of Hawaii. Both have agreed that the study of the Leeward Island chain should and could be a joint undertaking.

The task will then be extended to include accumulation and dissemination of information covering the assessment, development, and management of insular resources of island territories of U.S. concern; and will be terminated when the principal resources of commercial value have been identified, assessed, and their fisheries developed.

Senior Staff Members of Southwest Fisheries Center Honolulu Laboratory



RICHARD S. SHOMURA

Director, Honolulu Laboratory (Fishery Biologist, Research Administration)

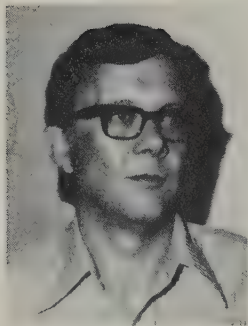
Born 1928. M.S. (Zoology), University of Hawaii, Honolulu, 1961. Joined NMFS Honolulu Laboratory, 1950-70; Southwest Region, 1970-71; Tiburon Fisheries Laboratory, 1971-73; Honolulu Laboratory, 1973.

AFFILIATIONS: American Fisheries Society, American Institute of Biological Sciences, American Institute of Fishery Research Biologists, American Museum of Natural History, American Society of Ichthyologists and Herpetologists, Ecological Society of America, Hawaiian Academy of Science. Member, Governor's Advisory Commission on Natural Area Reserve System.

FIELD: Ecology of marine fishes.

HONORS: Special Act Award, 1955; Quality Increase, 1966; BCF Honolulu Laboratory Nominee for Hawaii Federal Executive of the Year, 1966; Superior Performance Award, 1967.

PUBLICATIONS, 1950-73: Published, 31; in press 2.



RICHARD A. BARKLEY

Chief, Fish-Environment Investigations
(Oceanographer)

Born 1929. Ph. D. (Oceanography), University of Washington, Seattle, 1960. Joined NMFS Honolulu Laboratory staff, 1960.

AFFILIATIONS: Affiliate Graduate Faculty of the University of Hawaii, American Association for the Advancement of Science, American Chemical Society, American Geophysical Union, Hawaiian Academy of Science, Society of Sigma Xi. Member, Board of Editors, Journal of Marine Research, 1969-74; member, Board of Editors, Pacific Science, 1967-70.

FIELD: Theoretical and actual distributions of temperature, salinity, and other properties of the ocean. The characteristics of boundary layers, particularly island wake systems, and their influence on the nearby ocean.

HONORS: Superior Performance Award, 1964; BCF Honolulu Laboratory Nominee for Hawaii Federal Executive of the Year, 1968; Special Achievement Award, 1968; BCF Honolulu Laboratory Nomination for Arthur S. Fleming Award, 1968; Nomination for Fisheries Publication Award of the Wildlife Society, 1969; Meritorious Service Award of Department of the Interior, 1970.

PUBLICATIONS, 1961-73: Published, 12; in preparation, 2.



ROGER E. GREEN

Leader, Baitfishes and Bait Fishery Development
(Fishery Biologist, Research)

Born 1928. M.S., Stanford University, Stanford, 1958. Joined NMFS Southwest Fisheries Center, La Jolla Laboratory staff, 1962-71; Tiburon Fisheries Laboratory staff, 1971-73; Honolulu Laboratory staff, 1974.

AFFILIATIONS: San Francisco Bay and Estuarine Association, American Fisheries Society.

FIELD: Tuna fisheries and gear development.

HONORS: Incentive Award, 1966, 1973; Quality Increase, 1969.

PUBLICATIONS, 1962-73: Published, 9; in preparation, 3.



WILLIAM H. NEILL

Leader, Life Studies: Tuna and Tunalike Fishes
(Fishery Biologist, Research)

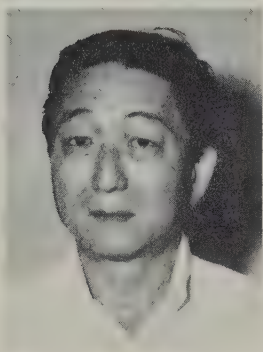
Born 1943. Ph. D. (Zoology with minor in statistics), University of Wisconsin, Madison, 1971. Joined NMFS Honolulu Laboratory staff, 1971.

AFFILIATIONS: Affiliate Graduate Faculty of the University of Hawaii, American Fisheries Society, American Institute of Biological Sciences, American Institute of Fishery Research Biologists, Society of Sigma Xi.

FIELD: Ecology, behavior, and physiology of fishes.

HONORS: Phi Eta Sigma, 1962; Phi Beta Kappa, 1964; National Science Foundation (NSF) Undergraduate Research Participant, 1964-65; NSF Cooperative Graduate Fellow, 1965-67; NMFS Honolulu Laboratory Nominee for Outstanding Young Federal Employee of the Year, 1973.

PUBLICATIONS, 1971-73: Published, 2; in press, 3; in preparation, 2.



TAMIO OTSU

Chief, Tuna Assessment and Development Investigations (Supv. Fishery Biologist, Research)

Born 1923. B.A. (Zoology), University of Hawaii, Honolulu, 1950. Joined NMFS Honolulu Laboratory staff, 1950.

AFFILIATIONS: American Fisheries Society, American Institute of Fishery Research Biologists, Hawaiian Academy of Science, International Oceanographic Foundation. Member, Working Party on Tuna Tagging, Food and Agriculture Organization of the United Nations; alternate member, Advisory Committee on Invertebrates and Aquatic Vertebrates, Board of Agriculture, State of Hawaii.

FIELD: Ecology of marine fishes of the Pacific Ocean.

HONORS: Bronze Star; Superior Performance Award, 1962; Outstanding Performance Award, 1969; BCF Honolulu Laboratory Nominee for Federal Manager of the Year, 1970.

PUBLICATIONS, 1950-73: Published, 34. Translations (from the Japanese), 28.



ROBERT A. SKILLMAN

Leader, Fishery Analysis Program (Fishery Biologist, Research)

Born 1941. Ph. D. (Zoology with studies in population ecology, population genetics, and biomathematics), University of California, Davis, 1969. Joined NMFS Honolulu Laboratory staff, 1969.

AFFILIATIONS: American Fisheries Society, Ecological Society of America, Hawaiian Academy of Science.

FIELD: Biomathematics, population ecology, population dynamics, ecology.

PUBLICATIONS, 1969-73: In press, 1; in preparation, 1.



PAUL J. STRUHSAKER

Leader, Purse Seine Fishery Development (Fishery Biologist, Research)

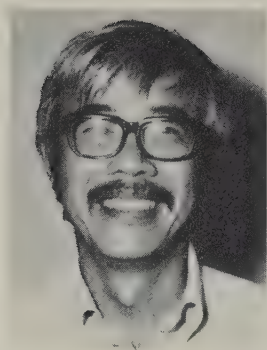
Born 1935. Ph. D. (Zoology), University of Hawaii, Honolulu, 1973. Joined NMFS Southeast Fisheries Center staff, 1959-65; Honolulu Laboratory staff, 1969.

AFFILIATIONS: American Society of Ichthyologists and Herpetologists, Hawaiian Academy of Science, Society of Systematic Zoologists. Research Associate, Bernice P. Bishop Museum.

FIELD: Fisheries development; ecology and systematics of marine fishes.

HONORS: Tri-Beta, Undergraduate Biology Honorary Society.

PUBLICATIONS, 1959-65, 1969-73: Published, 13; in press, 5; in preparation, 11.



HEENY S. H. YUEN

Leader, Recreational Fisheries (Fishery Biologist, Research)

Born 1926. M.S. (Fishery Biology), University of Hawaii, Honolulu, 1954. Joined NMFS Honolulu Laboratory staff, 1950.

AFFILIATIONS: American Association for the Advancement of Science, American Fisheries Society, American Institute of Biological Sciences, American Institute of Fishery Research Biologists, American Museum of Natural History, Hawaiian

Academy of Science, Society of Sigma Xi.

FIELD: Fishery biology.

PUBLICATIONS, 1950-73: Published, 17; in press, 1.



MARY LYNNE GODFREY

Chief, Technical Services (Supv. Scientific Information Specialist)

Born 1922. B.A., University of California, Los Angeles, 1943. Joined NMFS Honolulu Laboratory staff, 1950.

AFFILIATION: Hawaiian Academy of Science.

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HONORS: Phi Beta Kappa, 1943; Superior Performance Award, 1961; BCF Honolulu Laboratory Nominee for Outstanding Woman Federal Employee of the Year, 1967.

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STATUS OF RESEARCH AND FISHERIES - SKIPJACK TUNA (U.S.A.)¹

In 1956, Shimada and Schaefer (1956) showed that the catch of skipjack tuna in the eastern Pacific was not large enough to have a measurable effect on the stock. Since then a number of others have studied the skipjack tuna resource in the Pacific and have reached the same conclusion (Rothschild, 1966; Silliman, 1966; Joseph and Calkins, 1969). Despite evidence that it was possible to greatly increase the annual catch of skipjack tuna on a sustainable basis, the Pacific-wide catches of this species have not increased markedly.

A major reason for the lack of rapid expansion of the fishery is the unpredictable availability of the skipjack tuna to the fishermen. In the central Pacific, where fishing for skipjack tuna is conducted primarily with pole-and-line gear, the availability of live bait has also been a severe limiting factor.

The following sections provide a brief background and status of the U.S.A. fisheries for skipjack tuna in the Pacific Ocean.

EASTERN PACIFIC FISHERY

The eastern Pacific tropical tuna fishery is a complex fishery involving two principal methods of fishing, the pole and line and purse seine, and harvesting two principal species of tunas, the yellowfin and skipjack.

Historical Development

The fishery for skipjack tuna--and yellowfin tuna as well--in the eastern tropical Pacific is an outgrowth of the California albacore fishery, which began in 1903 (Shimada and Schaefer, 1956). In 1916, when albacore were scarce, small quantities of yellowfin and skipjack tunas, which previously had been overlooked in favor of albacore, were caught and canned.

World War I brought about an increased demand for canned tuna. Albacore alone could not satisfy this demand; therefore, large amounts of yellowfin and skipjack tunas were processed. In 1918, 77% of the pack of canned tuna was composed of yellowfin and skipjack tunas.

Following World War I, as albacore catches continued to be erratic and unpredictable, increasing quantities of yellowfin and skipjack tunas were caught. Whereas fishing was confined to the offshore waters

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of southern California in the early years of the fishery, the increased demand for yellowfin and skipjack tunas triggered an expansion of the fishing grounds to the Baja California region, an area where previous exploration had revealed an abundance of these species.

The expansion of the fishery also introduced the idea of using large refrigerated mother ships. Operating out of Mexican anchorages, the mother ships received the catches from the fleets of small California-based tuna fishing boats. The frozen fish were then transferred to tender ships for transshipment to southern California canneries.

Complications with the Mexican Government's policy concerning customs duties on transshipment of American-caught tuna to California discouraged further expansion of the tender-fleet type of operation. The result was the evolution of the modern high-seas tuna fishing boats which were capable of operating independently and profitably on the high seas. The character of the fishery thus changed from one of small boats dependent on tenders to that of large boats capable of independent operations.

Using pole and line and live bait to fish schools of yellowfin and skipjack tunas, these far-ranging tuna clippers were improved over the years so that they could fish tuna schools more efficiently. Engines were relocated farther forward to give the vessels increased hold capacity. The main house was enlarged. And eventually, a pilothouse was constructed atop the main house (McNeely, 1961).

In the early years, tuna purse seiners were also used in the fishery but were only moderately successful. Their operations, however, were profitable enough so that the fishermen continued using and improving this method of capturing tuna (Green, Perrin, and Petrich, 1971). These early seiners remained largely on local fishing grounds whereas the pole-and-line tuna clippers ventured as far south as Peru and developed familiarity with the distant fishing grounds. By the late 1950's, however, purse seine technology had improved to such an extent that the growing economic crises were all that was needed to bring together all the ingredients for a successful high-seas tuna purse seine fleet (Broadhead and Marshall, 1961).

With the introduction of all-nylon tuna nets used in conjunction with a Puretic "power block," a mechanical device for power hauling of nets, there began a "purse seine revolution" in the tuna fishing industry. McNeely (1961) described the mass conversion of the tuna fleet from predominantly pole-and-line clippers to seiners as an event unparalleled in the history of major U.S. fisheries. Considerable details on the history of both pole-and-line and purse seine fishing for tuna in the eastern Pacific can be found in Godsil (1938), Scofield (1951), Shimada and Schaefer (1956), McNeely (1961), and Green et al. (1971).

Methods of Capture

The present U.S. fleet of tuna fishing boats in the eastern Pacific is essentially dominated by purse seiners, although there still remains a number of small bait boats and trollers. In 1972, the Inter-American Tropical Tuna Commission (IATTC) reported (IATTC, 1973a) that the fleet consisted of 127 seiners and 52 bait boats for a total of 179 tuna fishing boats operating in the Commission Yellowfin Regulatory Area (CYRA). Table 1 gives the number of bait boats and seiners operating in the eastern tropical Pacific tuna fishery in 1950-72.

Table 1.--Long-range California- and Puerto Rico-based vessels fishing in the eastern tropical Pacific tuna fishery, 1950-72.

Year	Bait boats	Purse seiners	Total
1950	204	67	271
1951	228	78	303
1952	202	64	266
1953	190	64	254
1954	182	69	251
1955	172	63	235
1956	175	64	239
1957	170	50	220
1958	159	44	203
1959	140	53	193
1960	70	83	160
1961	44	114	158*
1962	36	103	139
1963	30	111	141
1964	35	111	146
1965	44	111	155
1966	52	102	154
1967	46	101	147
1968	50	104	154
1969	43	114	157
1970	44	121	165
1971	48	124	172
1972	52	127	179

*Does not include about 22 others (mostly under U.S.A. flag) based in Costa Rica, Mexico, and Peru.

Source: Data for 1950-69 are from Green et al. (1971). Data for 1970-72 are from Annual Reports of the IATTC for 1970 (1971), 1971 (1972), and 1972 (1973a).

Today's modern tuna seiner has a large carrying capacity and ranges in length from 42.4 m to more than 76 m (Green et al., 1971). While the carrying capacity of the largest seiners prior to 1961 was about 590 metric tons, those built after 1961 averaged 655 metric tons and the largest nearly 830 metric tons. Large seiners of over 1,000 metric tons carrying capacity have joined the fleet in recent years.

Conversion from pole-and-line fishing to seining required completely new types of equipment and gear. Bait tank piping, circulating pumps, fishing racks, and accessory gear were removed. In their place were installed the various components of seine fishing gear. Besides the purse seine and power block, the gear included auxiliary speedboats, masts and booms capable of withstanding the stresses of net hauling, "drying up," and lifting aboard the heavy seine skiff. Seining operations also required heavy-duty winches, hydraulic drive systems, and other deck accessories and installations. McNeely (1961) gives an excellent detailed account of the conversion of vessels from pole-and-line fishing to purse seining.

Details of the purse seine fishing operations may be found in McNeely (1961) and Green et al. (1971). The brief description of the operation given here is taken from both of these reports.

Initially, the operation involves preparation of the purse seine and seine skiff for a set. After the net is stacked properly, the seine skiff is lifted to its position atop the net pile. When fish are sighted and the vessel moves into position for a set, the seine skiff with the net end attached is allowed to drop into the water. The skiff acts as a sea anchor and pulls the first portion of the net over the stern.

A "fishing captain" or airborne observer controls the encircling operation. At the completion of the set, the hauling line is released from the skiff and taken aboard the vessel. The skiff is then free to patrol the open waters or take up its position at the opposite side of the vessel.

The net is pursed until the rings are together. When the rings are out of the water and free, hauling of the net begins. The net is hauled and stacked until the area occupied by the fish is minimal.

Brailing then begins. The brail is guided into the captured fish in the net and takes a full scoop of fish which is then positioned over an unloading hopper on the seiner. Fish unloaded into the hopper are guided to selected brine tanks by a series of metal chutes. After brailing is completed, the net and skiff are prepared for the next set.

The pole-and-line method of tuna fishing used by the eastern Pacific fishery has been described in numerous publications (Godsil, 1938; Shimada and Schaefer, 1956). Briefly, the boat first obtains

bait from the baiting grounds and proceeds to the fishing grounds to scout for schools of tuna. Live bait is the key to this type of operation; therefore, considerable time and effort are expended in locating, capturing, and transporting bait from the baiting to fishing grounds. The amount of bait carried by a bait boat varies; it may be as much as several hundred scoops (a scoop is equivalent to about 3.2 kg of bait) for the eastern Pacific bait boats. The most important bait species in the eastern Pacific fishery is the anchoveta, Cetengraulis mysticetus, a tropical anchovy of wide distribution (Shimada and Schaefer, 1956). Other important bait species are the Galapagos sardine, Sardinops sagax, and the northern anchovy, Engraulis mordax.

On the fishing ground, the fishermen scout for tuna schools and when one is located, the vessel intercepts the school and chums it with live bait. Fishermen stationed in the fishing racks at the stern and along the gunwales near the stern begin fishing as the school is attracted close to the vessel by the chum. While in a state of feeding excitement, the tuna strike at the feathered lures which are cast among the frenzied fish. When hooked, the fish are pulled out of the water and into the boat.

Area and Scope of Operation

In the eastern Pacific, both yellowfin and skipjack tunas occur in the same general fishing grounds. There are, however, some differences in the distribution of these two species. Skipjack tuna may be captured in commercial quantities in waters as cool as 16°C. Yellowfin tuna, on the other hand, are seldom taken in waters colder than 18°C (Broadhead and Orange, 1960). Furthermore, skipjack tuna fishing in the eastern Pacific is concentrated in two areas; the major one occurs between lat 5°N and 10°S, with a secondary area at about the tip of Baja California between lat 20° and 25°N. The Annual Report of the IATTC (1973a) indicates that catch and estimates of abundance in the southern area are usually twice as large as in the northern area.

The advent of a quota system for catching yellowfin tuna within the CYRA resulted in a short fishing season for this species each year, e.g. the 1973 season opened on January 1 and closed on March 8 (IATTC, 1973b). Although skipjack tuna can be taken without restriction within the CYRA, the fleet found itself faced with the alternative of fishing exclusively for skipjack tuna or looking for yellowfin tuna outside the CYRA. While some of the vessels chose to range westward into the high-seas areas outside the traditional fishing grounds of the eastern tropical Pacific, others moved eastward into the Atlantic and have ventured as far as the African coast (Green et al., 1971). Since 1967, there has been a steady increase in the number of vessels that have fished for yellowfin tuna off the west coast of Africa after the closure date for yellowfin tuna season in the eastern tropical Pacific. In fact, many of the new seiners have selected Puerto Rico as their home port, thus beginning a shift away from southern California as the center of U.S. tuna

production. The 1972 listing of the American high-seas tuna fleet shows that of 147 vessels, 37 have selected either San Juan or Mayaguez, Puerto Rico as home port. Roughly half of the fleet, however, continues to operate out of San Diego, California (Anonymous, 1973).

Catch

The catch of skipjack tuna in 1968-72 from the eastern Pacific Ocean is given in Table 2 together with catches made in Hawaii and in the Atlantic Ocean by U.S. tuna fishermen.

Table 2.--Annual skipjack tuna catch in metric tons for the eastern Pacific, Hawaii, and the Atlantic by U.S. fishermen.

Year	Eastern Pacific Ocean ¹	Hawaii ²	Atlantic Ocean ³
1968	70,444	4,227	3,219
1969	58,605	2,705	3,800
1970	50,077	3,334	⁴ 10,736
1971	103,058	6,051	⁴ 16,921
1972	⁴ 31,525	4,952	⁴ 12,167

¹Data for the eastern Pacific are from IATTC (1973a).

²Data for Hawaii are from catch records of the Hawaii Division of Fish and Game.

³Data for the Atlantic are from Miyake and Tibbo (1973).

⁴Preliminary figures.

The catch and abundance of skipjack tuna varies considerably from year to year. Scientists at the IATTC report that this variability does not appear to be related to fishing intensity on the parent stock, but rather to natural factors. Table 2 shows the extent of the high variability in the skipjack tuna landings of the eastern Pacific; the catch in 1971 (103,058 metric tons) is more than double that of 1970 (50,077 metric tons), while the 1972 catch (31,525 metric tons) is down sharply to less than a third of the landings made in the previous year. The record of 122,381 metric tons was made in 1967 with the 1971 catch being the second highest in the history of the fishery.

In the eastern Pacific, fishing tends to be somewhat seasonal at the extremes of the fishing ground (off Baja California and the

regions off South America). In the Central American region, the season is less marked and may persist over a period of 6 months (Waldron, 1963).

HAWAIIAN FISHERY

Unlike the eastern Pacific tropical tuna fishery, the Hawaiian fishery is strictly a one-method, one-species operation. Although small yellowfin tuna and little tunny are taken on occasion by this fishery, the bulk of the annual catch made by the pole-and-line fishery is the skipjack tuna.

Historical Development

The seasonal appearance of skipjack tuna in Hawaii was the basis for a subsistence fishery for the early Hawaiians. Venturing far offshore in outrigger canoes, the Hawaiians sought the schools of skipjack tuna as they entered waters adjacent to the small villages scattered throughout the islands (June, 1951).

Commercial development of the skipjack tuna fishery in Hawaii began about 1900. With the introduction of Japanese fishing sampans and gear, the fishery expanded rapidly. The early sampans were small, usually propelled by a scull or by sail, and crewed by four to six men.

In 1907, gasoline-powered boats were introduced, thus making it possible to expand fishing operations farther offshore. The vessels were gradually improved with the addition of the flying bridge, a pump-spray system, and changes in the hull design to allow greater freeboard forward.

Method of Capture

Prior to 1971, all Hawaiian skipjack tuna sampans were built of wood. Two steel-hulled vessels, originally built for other marine uses, were converted into skipjack tuna fishing sampans in 1947. Today's fleet is comprised of vessels built as early as 1926 and as recently as 1971. The vessels that dominate fishing, however, are the sampans of the immediate post-World War II period. These vessels are characterized by their large bait-carrying capacities (Uchida, 1966).

The newest and most recent addition to the Hawaiian fleet is the steel-hulled Anela built in 1971. It has a cruising speed of 13.8 knots and cruising range of 3,700 km. The registered length is 26.6 m, the beam 7.6 m, and the depth 3.6 m. Gross and net tonnages are 136 and 91 metric tons, respectively (Uchida and Sumida, 1973). The other vessels in the fleet range from 17.8 m to 24.5 m in registered length and from 24.5 to 69.8 metric tons in gross tonnage.

All of the Hawaiian sampans carry 5 to 14 men per fishing trip. The boats have six baitwells arranged on the afterdeck in two parallel rows of three. Varying with the size of the vessel, the bait capacities of these sampans range from about 25 buckets for the small vessels to 130 for the largest one. Emptied of bait during fishing, the baitwells serve as stowage area for the catch. All vessels built prior to 1971 carry ice to refrigerate; the Anela, however, has a pump system to circulate refrigerated seawater.

The method of fishing is basically the same as in the eastern Pacific pole-and-line fishery. Details of the Hawaiian fishing method can be found in June (1951).

Area and Scope of Operation

Hawaiian skipjack tuna sampans are short-ranged vessels and usually operate close to land; seldom venturing more than 170 km from land. The area of fishing operation covers roughly 181,000 sq km. The trips usually last 1 day. Most trips originate between 0200 and 0600 and terminate at 1800 and 2200. An average trip lasts 15.5 hours; of this, 4.8 hours is spent traveling to and from the fishing grounds (Uchida and Sumida, 1971).

Although the small Hawaiian fleet ranges over an extensive area in pursuit of the skipjack tuna, most of the effort is concentrated near shore. Uchida (1967) has estimated that from 60% to 90% of the annual landings of skipjack tuna come from within 37 km of the main islands. Geographically, most vessels fish around the island of Oahu probably because most of the vessels are based there. In 1973, there were 12 boats operating out of Oahu, 2 out of Maui, and 1 out of Hawaii. In 1948-65, 50% of the catch was made off Oahu, 28% off Maui, Molokai, and Lanai, 13% off Hawaii, and 9% off Kauai and Niihau (Rothschild and Uchida, 1968; Uchida, 1970).

It is possible for the Anela to operate in other areas of the Pacific Ocean. This vessel has the capability of traveling to distant ports throughout the central and western Pacific to conduct pole-and-line fishing operations. In early 1972, while under charter to the National Marine Fisheries Service (NMFS), Southwest Fisheries Center, Honolulu Laboratory, the Anela sailed to the Marshall Islands and American Samoa, two areas that have been under consideration as potential bases for commercial skipjack tuna fishery development by the Pacific Islands Development Commission (Uchida and Sumida, 1973). The results of this exploratory cruise disclosed that the availability of skipjack tuna in waters of the Marshall Islands and American Samoa was impressive. Live bait was plentiful in the Marshall Islands, but scarce in American and Western Samoa. To conduct fishing trials in American Samoa, therefore, the vessel caught bait in Fiji and transported it back to American Samoa. At Fiji, the Anela found both tuna and live bait in abundance.

Catch

The Hawaiian skipjack tuna fishery is highly seasonal. Catches are usually lowest early in the year then increase gradually from about April to a peak in June, July, and August (Figure 1). After the northern summer season the catches decline progressively to a low level in December. About three-fourths of the annual landings are made in May-September.

In 1968-72, the skipjack tuna catches from Hawaiian waters averaged 4,254 metric tons and ranged between 2,705 metric tons in 1969 and 6,051 metric tons in 1971 (Table 2). The record catch of 7,329 metric tons was made in 1965 whereas the lowest catch was made in 1969.

The size of skipjack tuna available in Hawaiian waters ranges from small fish (less than 4.8 kg) to large skipjack tuna weighing over 12.6 kg. The bulk of the catch during the height of the fishing season is made up of fish averaging 8.1 kg (Figure 2).

PROBLEMS

Although skipjack tuna catches are not regulated in the eastern Pacific, it is essential that fishery scientists understand the natural variability in skipjack tuna catch and abundance. For example, does variability in the catch represent changes in real abundance of the entire stock or merely reflect changes in availability of part of the stock? Proper management of the stock cannot be undertaken without an understanding of this variability and its effect on the catch.

At the World Scientific Meeting on the Biology of Tunas and Related Species, Chapman (1963) brought out the importance of the application of ocean research to the increased production of tuna from the sea. He said:

"Essentially what is wanted is to relate the circulation of the lower atmosphere with the circulation of the upper ocean, relate the circulation of the upper ocean with the aggregation of tuna in space and time, and relate the behavior of tuna to oceanic conditions, all to the end that the fishermen can locate, catch and land a load of tuna in the quickest time possible, with the highest reliability of being able to do it again, and with the lowest possible cost per ton of production. What is aimed at is reliable prediction of tuna aggregation in time and space from parameters of ocean or air conditions readily and customarily measured."

Attempts at finding such relationships between the occurrence of skipjack tuna and the environmental conditions have been discussed by Seckel (1963, 1972). He has suggested that the current system in the North Pacific is an important cause of variations in the availability

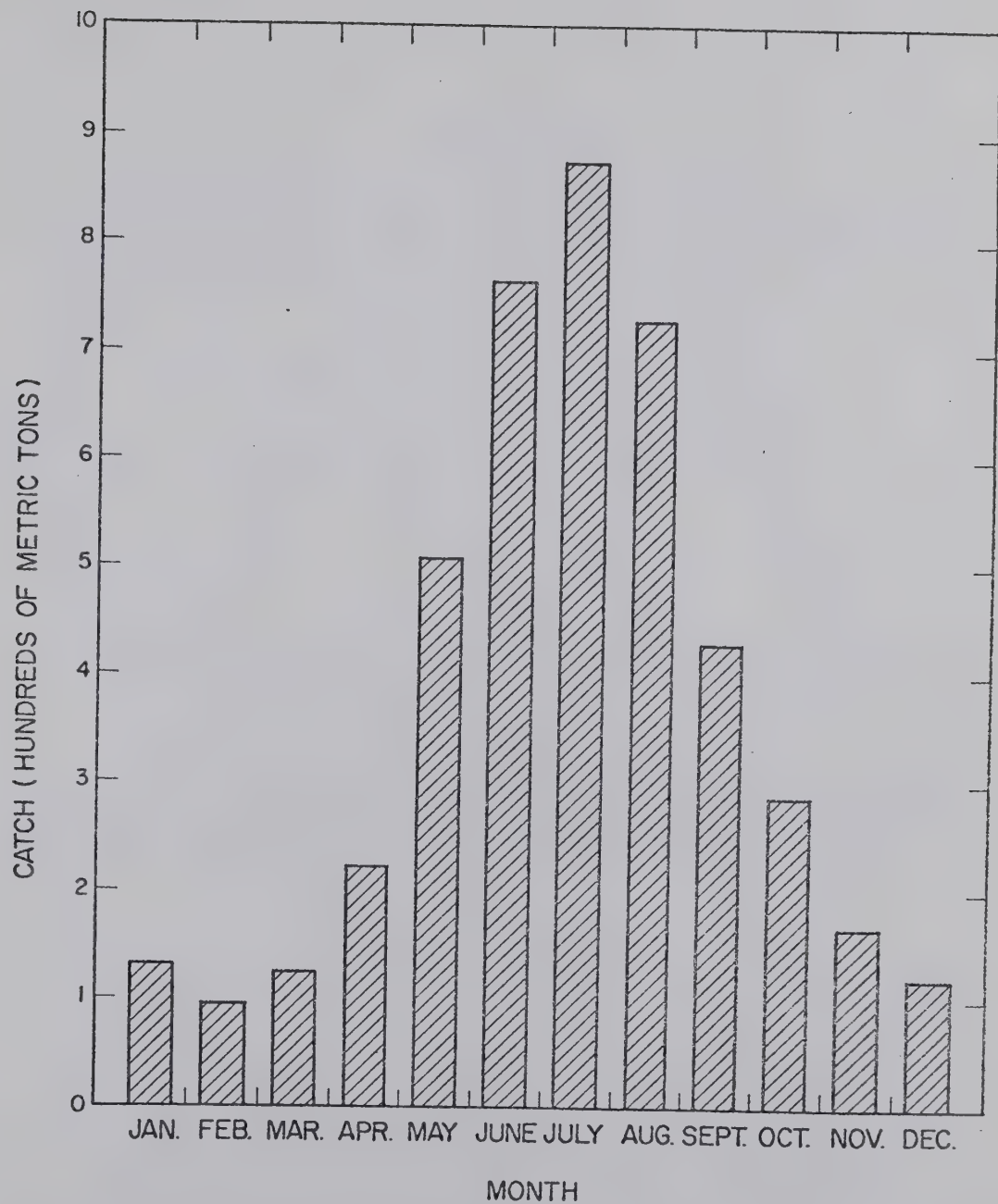


Figure 1.--Average monthly catch of skipjack tuna from Hawaiian waters, 1948-72.

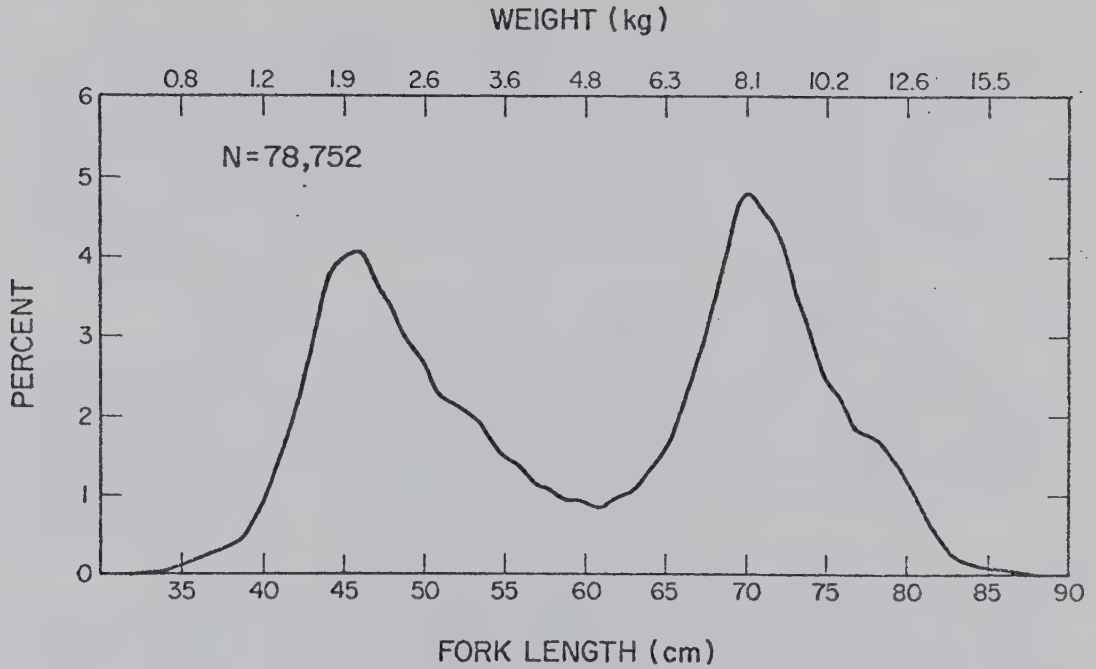


Figure 2.--Size composition of the commercial landings of skipjack tuna in the Hawaiian fishery (from data files, Bureau of Commercial Fisheries Biological Laboratory, Honolulu) (from Waldron, 1963).

of skipjack tuna in Hawaiian waters. A numerical drift model was used to investigate the contribution of currents to the travel of skipjack tuna from the eastern North Pacific to Hawaii. But models require verification before they can be used effectively to predict the catch.

In the eastern Pacific, scientists at IATTC are investigating the relationship between sea-surface temperatures in the spawning areas and skipjack tuna abundance in the fishing areas (IATTC, 1973b). The reasoning is that since the number of skipjack tuna larvae increases with temperature, warm years in the central Pacific spawning areas may result in higher indices of apparent abundance in the fisheries of the eastern Pacific. The recruits entering the eastern Pacific are believed to be 1 to 2 years old; therefore, variations in spawning or survival of larvae may be reflected in the fishing in about one and a half years.

Correlation between various indices of skipjack tuna abundance and those of sea-surface temperature and atmospheric pressure one and a half years earlier were significant in 28 out of 31 tests. The results indicated that there is a relationship between skipjack tuna abundance in the eastern Pacific and sea-surface temperature in the central equatorial Pacific. But because temperature may not be the single causal factor, but merely reflecting fluctuations in oceanographic conditions, other environmental factors have been examined.

In 1973, IATTC scientists estimated the apparent abundance and catch for 1973 and 1974, using the Darwin, Australia barometric pressure anomalies (IATTC, 1973b). They estimated the total skipjack tuna catch for 1973 to be 44,450 metric tons (49,000 short tons) which approximated the actual catch of roughly 43,540 metric tons (48,000 short tons). For 1974, their estimate is 120,650 metric tons (133,000 short tons).

Beginning in 1969, tuna tagging experiments also received considerable emphasis. With fishing effort expanding rapidly 1,000 to 3,000 km offshore, there was an urgent need to know more about the extent of mixing among the fish of various inshore and offshore areas (IATTC, 1973a). Although yellowfin tuna tagging experiments have received much more emphasis because of the heavy exploitation of this species, large numbers of skipjack tuna have also been tagged. Almost equal numbers of skipjack and yellowfin tunas were tagged in the eastern Pacific in 1973. The IATTC (1973b) reported that in 1973, 1,938 skipjack tuna and 1,927 yellowfin tuna were tagged. Recapture totaled 464 skipjack tuna and 115 yellowfin tuna.

In an effort to determine whether it is possible to induce formation of permanent marks in bones and scales of tuna, IATTC scientists are also conducting live-tank experiments on Pacific mackerel, Scomber japonicus (IATTC, 1973b). By this method, it is hoped that growth rates and age can be estimated. Pacific mackerel, tagged and injected intramuscularly with various dosages of tetracycline, were autopsied after

removal from the live tank and were found with tetracycline deposited in bones, scales, and other body organs. The smallest dosage used, 10 mg/kg of fish, was readily detected under ultraviolet light. These experiments are continuing.

Because the two-species tuna fishery of the eastern tropical Pacific depends on skipjack tuna as well as yellowfin tuna, it is difficult to separate the problems encountered by the fishermen in capturing yellowfin tuna from those encountered while fishing for skipjack tuna. One of the most pressing problems today is the mortalities among two species of porpoise, Stenella graffmani and S. longirostris, both of which are found in close association with schools of yellowfin. About half of the yellowfin tuna caught by seiners is taken from schools associated with porpoise (Green et al., 1971).

In making a set around a yellowfin tuna school associated with porpoise, the problem is then to separate unwanted porpoise from the valuable tuna. To accomplish the separation with the least possible mortality to the porpoise, the fishermen have developed a method called "backing down." The purpose is to allow the porpoise to spill over the corkline of the net and at the same time retain the yellowfin tuna. Despite this operation to save the porpoise, some are inadvertently entangled in the net and drown. The NMFS, Southwest Fisheries Center, La Jolla Laboratory has, in recent years, initiated programs to research and develop improved fishing methods and gear that would reduce porpoise mortality as required by the Marine Mammal Protection Act of 1972. Data are also being collected for a study of the dynamics of the porpoise population.

To be competitive with foreign tuna fisheries, U.S. fishermen must also constantly seek ways to improve the efficiency of harvesting the skipjack tuna resource. Green et al. (1971) cite a number of areas in which the tuna fleet could upgrade its efficiency to cope with rising costs and competition with low-cost foreign tuna producers. Improved refrigeration and partial processing at sea may increase the value of the catch. Transferring of the catch from the net to the boat should become more mechanized to reduce time lost in these operations on the fishing grounds. Furthermore, reduction of off-loading time should reduce turn-around time for the boats.

Other improvement could be made in the vessel's power plant, in net handling, in the deck equipment for handling the catch, in the net itself, and in scouting for fish schools (Green et al., 1971).

The key to the establishment and expansion of pole-and-line fisheries for skipjack tuna is the availability of live bait; this problem is particularly acute in the Hawaiian Islands. The availability of the native baitfish, nehu, varies widely and there is usually a shortage of baitfish from May through September when fishing for skipjack tuna becomes very intense. Most vessels expend much time and effort in

capturing sufficient bait to fish skipjack tuna. In recent years, the time spent in day baiting was about 40% of the total daytime activity of the fleet. Obviously, a reduction in the time spent day baiting would provide more time for fishing. An increase in fishing effort should increase the landings of skipjack tuna proportionately.

The problem of providing supplemental bait to the skipjack tuna fishing boats has a history that goes back at least two decades. In November 1953-October 1954, an early baitfish research program of the Hawaii Division of Fish and Game evaluated the suitability of Tilapia mossambica, a freshwater cichlid, as live bait for the fishery. The results of the field trials indicated that tilapia was suitable for skipjack tuna fishing and was subsequently cultivated on a large scale (Brock and Takata, 1955; King and Wilson, 1957; Hida, Harada, and King, 1962; Uchida and King, 1962). The failure of tilapia as a viable supplemental baitfish was attributed to the reluctance among the fishermen to purchase tilapia consistently.

Other species have also been tried. Marquesan sardine, Sardinella marquesensis, was introduced into Hawaiian waters, but this species never became established in quantity (Hida and Morris, 1963). Threadfin shad, Dorosoma petenense, a freshwater fish with excellent qualities as tuna bait, was also introduced into freshwater reservoirs around the islands (Hida and Thomson, 1962). This species became well established in one reservoir on Oahu and the production from it was sufficient for comprehensive field trials by vessels of the NMFS and the skipjack tuna fleet (Iversen, 1971). But unlike tilapia, shad was not cultured in captivity. Capturing and transporting shad from the reservoir to the docks, and acclimating them to seawater before transfer to the baitwells were problems that eventually proved too costly for an economically feasible operation. Work has also been done with sharpnosed molly, Poecilia sphenops, as skipjack tuna bait (Herrick, unpublished²; Baldwin, 1974).

Another approach to the solution of the acute bait shortages during the summer is to transport bait from areas where it is readily available. In 1973, a proposal to transport the northern anchovy, Engraulis mordax, from California to Hawaii met with enthusiastic support from the fishermen. The northern anchovy has been brought to Hawaii in the past on several occasions. All indications were that this species was hardier than nehu and also acceptable to the local fishermen. Acceptability was shown by a willingness of fishermen to purchase such

²Herrick, S. F., Jr. 1972. Economic analysis of commercial molly (Poecilia sphenops) baitfish aquaculture. 11 p. and attachments. Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI 96744.

bait. Consequently, the NMFS, Southwest Fisheries Center, Honolulu Laboratory initiated a program to transport the northern anchovy into Hawaii. They provided the expertise to carry out a study to determine the feasibility of transporting live anchovy in a 19,000-liter (5,000 gallons) aircraft refueling trailer that was modified to haul fish. The system included a self-contained, life-support system. The transport vehicle will use to its advantage the roll-on/roll-off cargo handling system developed by the U.S. maritime industry to move bulk cargo. At present, the work on this project is progressing at a satisfactory rate.

Although providing supplemental bait may be a partial solution to the bait shortages experienced by the Hawaiian skipjack tuna fishermen, it is not the only means of increasing the supply of usable bait. Nehu is notoriously vulnerable to mortality from handling; therefore, about a third of the nehu caught in Hawaiian waters do not survive long enough to be used as bait for fishing. Brock and Uchida (1968) estimated that 25% or more of the bait may die within 24 hours after capture. Baldwin, Struhsaker, and Akiyama (1972), therefore, evaluated survival of baitfish in the sampan's baitwells and developed equipment and techniques to avoid some of the causes of nehu mortalities.

Acute temporary shortages and high mortalities of nehu are not the only problems faced by the skipjack tuna fishermen. Another problem that arises from time to time is that of competition between commercial skipjack tuna fishermen and other users of baitfish species.

LITERATURE CITED

Anonymous.

1973. American high seas tuna fleet. In Pacific Packers Report
1973. Suppl. Natl. Fish. 53(12):29, 31, 33.

Baldwin, Wayne J.

1974. Raising mollies for skipjack bait may eliminate use of
frail nehu. Natl. Fish. 54(9):7C.

Baldwin, W. J., J. W. Struhsaker, and G. S. Akiyama.

1972. Longer life for nehu. [In English and Japanese.] Univ.
Hawaii Sea Grant Program MS-71-01 A, 24 p.

Broadhead, Gordon C., and Arthur R. Marshall.

1961. New methods of purse seining for tuna in the eastern
Pacific Ocean. Proc. Gulf Caribb. Fish. Inst., 13 Annu. Sess.,
p. 67-73.

Broadhead, Gordon C., and Craig J. Orange.

1960. Species and size relationships within schools of yellowfin and skipjack tuna, as indicated by catches in the eastern tropical Pacific Ocean. Bull. Inter-Am. Trop. Tuna Comm. 4:447-492.

Brock, Vernon E., and Michio Takata.

1955. Contribution to the problems of bait fish capture and mortality together with experiments in the use of tilapia as live bait. Territory of Hawaii, Industrial Research Advisory Council Grant 49, Final Report, 39 p.

Brock, Vernon E., and Richard N. Uchida.

1968. Some operational aspects of the Hawaiian live-bait fishery for skipjack tuna (Katsuwonus pelamis). U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 574, 9 p.

Chapman, Wilbert M.

1963. World-wide tuna research planning. In H. Rosa, Jr. (editor), Proc. World Sci. Meet. Biol. Tunas Related Species. FAO (Food Agric. Organ. U.N.) Fish. Rep. 6:1097-1107.

Godsil, H. C.

1938. The high seas tuna fishery of California. Calif. Dep. Fish Game, Fish Bull. 51, 41 p.

Green, R. E., W. F. Perrin, and B. P. Petrich.

1971. The American tuna purse seine fishery. In Hilmar Kristjonsson (editor), Modern fishing gear of the world 3:182-194. Fish. News (Books) Lond.

Hida, Thomas S., Joseph R. Harada, and Joseph E. King.

1962. Rearing tilapia for tuna bait. U.S. Fish Wildl. Serv., Fish. Bull. 62:1-20.

Hida, Thomas S., and Robert A. Morris.

1963. Preliminary report on the Marquesan sardine, Harengula vittata, in Hawaii. Pac. Sci. 17:431-437.

Hida, Thomas S., and Donald A. Thomson.

1962. Introduction of the threadfin shad to Hawaii. Prog. Fish-Cult. 24:159-163.

Inter-American Tropical Tuna Commission.

1971. Annual report of the Inter-American Tropical Tuna Commission, 1970. La Jolla, Calif., 127 p.

1972. Annual report of the Inter-American Tropical Tuna Commission, 1971. La Jolla, Calif., 129 p.

Inter-American Tropical Tuna Commission.

1973a. Annual report of the Inter-American Tropical Tuna Commission, 1972. La Jolla, Calif., 166 p.

1973b. The bi-monthly report of the Inter-American Tropical Tuna Commission. [1973 bi-monthly reports for January-February, March-April, May-June, July-August, September-October, November-December.] La Jolla, Calif.

Iversen, Robert T. B.

1971. Use of threadfin shad, Dorosoma petenense, as live bait during experimental pole-and-line fishing for skipjack tuna, Katsuwonus pelamis, in Hawaii. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-641, 10 p.

Joseph, James, and Thomas P. Calkins.

1969. Population dynamics of the skipjack tuna (Katsuwonus pelamis) of the eastern Pacific Ocean. Bull. Inter-Am. Trop. Tuna Comm. 13:1-273.

June, Fred C.

1951. Preliminary fisheries survey of the Hawaiian-Line Islands area. Part III - The live-bait skipjack fishery of the Hawaiian Islands. Commer. Fish. Rev. 13(2):1-18.

King, Joseph E., and Peter T. Wilson.

1957. Studies on tilapia as skipjack bait. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 225, 8 p.

McNeely, Richard L.

1961. The purse seine revolution in tuna fishing. Pac. Fish. 59: 27-58.

Miyake, Makoto P., and C. Gail Tibbo (compilers).

1973. Statistical bulletin of the International Commission for the Conservation of Atlantic Tunas. Stat. Bull. 3.

Rothschild, Brian J.

1966. Preliminary assessment of the yield potential of the skipjack tuna in the central Pacific Ocean. In Thomas A. Manar (editor), Proc. Governor's Conference on Central Pacific Fishery Resources, State of Hawaii, p. 251-258.

Rothschild, Brian J., and Richard N. Uchida.

1968. The tuna resources of the oceanic regions of the Pacific Ocean. In DeWitt Gilbert (editor), The future of the fishing industry of the United States, p. 19-51. Univ. Wash., Publ. Fish. N.S. 4.

1

Scofield, W. L.

1951. Purse seines and other roundhaul nets in California. Calif. Dep. Fish Game, Fish Bull. 81, 83 p.

Seckel, Gunter R.

1963. Climatic parameters and the Hawaiian skipjack fishery. In H. Rosa, Jr. (editor), Proc. World Sci. Meet. Biol. Tunas Related Species. FAO (Food Agric. Organ. U.N.) Fish. Rep. 6:1201-1208.

1972. Hawaiian-caught skipjack tuna and their physical environment. Fish. Bull., U.S. 70:763-787.

Shimada, Bell M., and Milner B. Schaefer.

1956. A study of changes in fishing effort, abundance, and yield for yellowfin and skipjack tuna in the eastern tropical Pacific Ocean. Bull. Inter-Am. Trop. Tuna Comm. 1:347-469.

Silliman, Ralph P.

1966. Estimates of yield for Pacific skipjack and bigeye tunas. In Thomas A. Manar (editor), Proc. Governor's Conference on Central Pacific Fishery Resources, State of Hawaii, p. 243-249.

Uchida, Richard N.

1966. The skipjack tuna fishery in Hawaii. In Thomas A. Manar (editor), Proc. Governor's Conference on Central Pacific Fishery Resources, State of Hawaii, p. 147-159.

1967. Catch and estimates of fishing effort and apparent abundance in the fishery for skipjack tuna (Katsuwonus pelamis) in Hawaiian waters, 1952-62. U.S. Fish Wildl. Serv., Fish. Bull. 66:181-194.

1970. Distribution of fishing effort and catches of skipjack tuna, Katsuwonus pelamis, in Hawaiian waters, by quarters of the year, 1948-65. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 615, 37 p.

Uchida, Richard N., and Joseph E. King.

1962. Tank culture of tilapia. U.S. Fish Wildl. Serv., Fish. Bull. 62:21-52.

Uchida, Richard N., and Ray F. Sumida.

1971. Analysis of the operations of seven Hawaiian skipjack tuna fishing vessels, June-August 1967. U.S. Dep. Commer., Natl. Mar. Fish. Serv., Spec. Sci. Rep. Fish. 629, 25 p.

1973. Tuna: Pole-and-line fishing trials in central and western Pacific. Mar. Fish. Rev. 35(1-2):31-41. (Also Mar. Fish. Rev. reprint No. 962.)

Waldron, K. D.

1963. Synopsis of biological data on skipjack Katsuwonus pelamis (Linnaeus) 1758 (Pacific Ocean). In H. Rosa, Jr. (editor), Proc. World Sci. Meet. Biol. Tunas Related Species. FAO (Food Agric. Organ. U.N.) Fish. Rep. 6:695-748.

March 20, 1974

Fl42

Brian J. Rothschild, Director, SWFC

Richard S. Shomura, Director, Honolulu Laboratory

Trip report - Meeting of Expert Committee on Tropical Skipjack
(February 25 to March 1, 1974, Papeete, Tahiti)

I departed Honolulu on 20 February 1974. My itinerary included a stopover in American Samoa (Feb. 20-24) prior to attendance of the meeting of the Expert Committee on Tropical Skipjack in Papeete, Tahiti (Feb. 25 to March 1). I departed Papeete on 4 March and returned to Honolulu on 5 March. The following provides a brief summary of my trip:

Shad (*Dorosoma petenense*) transport to Tahiti. At the request of Centre National pour l'Exploitation des Oceans (CNEOX) in Tahiti, we made a second attempt to transport live shad to Tahiti. An earlier attempt made several months ago failed when none of the shad survived the trip. On this last attempt 6 lots of 25 fish were placed in sea water in large plastic bags. Each plastic bag was placed in a separate styrofoam container. The shipment accompanied me on the trip as cargo. Our plan was to ship the shad in two stages; the first from Hawaii to American Samoa and then from American Samoa to Tahiti. Upon arrival at American Samoa we opened the boxes at the Laboratory of the Marine Resources Department of American Samoa and discovered that nearly all of the shad were dead. Six specimens were still living; these were transferred to a separate container and aerated. New sea water was placed into the container. The following day, 5 of the remaining 6 shad were reported dead.

Since CNEOX is still very much interested in obtaining shad, we plan to review our procedures, develop new handling and shipping techniques and carry out a third trial.

American Samoa (Feb. 20-24)

Meeting with Governor Haydon. I met with Governor Haydon for several hours at his office to discuss fisheries matters. We had an opportunity to review the PIDC meeting which had taken place the previous week in Honolulu. I informed Governor Haydon that I looked at PIDC with considerable promise, especially since tentative financial commitments have been received from industry and that he, as the newly elected Chairman of PIDC, and Mr. Schoning, as the new Director of NMFS, would provide the much needed guidance. Governor Haydon indicated that he would be extremely delighted if a skipjack fishery could be developed and based out of American Samoa. Needless to say the reliance on foreign fleets for tuna has created mixed feelings among elements in government and industry.

Bait-rearing project. I discussed the bait-rearing project with Dr. Swerdloff, Director of the Department of Marine Resources. Dr. Swerdloff indicated that production of the mollies to date has not been as high as initially projected. Some problems have been encountered in their holding ponds. Also, there was some concern that the growth rates of the mollies was considerably less than they had hoped for. I believe Dr. Swerdloff indicated that on one of the two limited field trials conducted to date they were able to catch some skipjack with mollies. He did, however, state that these trials were very limited.

On Saturday, 23 February 1974, I participated on a brief field trial using approximately 1-1/2 buckets of small sized mollies. We used the smaller 28-ft. vessel owned by the American Samoa Department of Marine Resources. The larger vessel, ALAPAGA, was inoperable at the time. Unfortunately, we did not see any skipjack schools until late afternoon. We were unsuccessful in raising a school of large (20-lb.) skipjack tuna with the mollies. Field conditions were not optimal; e.g., late afternoon (approaching darkness), rain squalls, and small amount and size of mollies. During the course of the day the mollies proved to be extremely hardy; low mortality experienced despite the extreme rough conditions. With reference to the future of the baitfish culture work in American Samoa, Dr. Swerdloff is expecting Wayne Baldwin from the HINB to visit Samoa shortly to assist with the project. I believe the presence of Wayne Baldwin will help overcome some of the problems Dr. Swerdloff has encountered in production, survival and growth. Assuming good production, the critical part of the project is to obtain adequate field trials.

Bumble Bee cannery plans. Based on recent newspaper accounts Castle and Cooke's plan to build a cannery in American Samoa appeared to be a firm fact. During my brief stay in American Samoa, I found out that it does not appear as a "sure" thing. I understand that the local politicians are extremely disturbed about Bumble Bee's plans to open a cannery in American Samoa. They are principally concerned with the demands that another cannery will place on their limited supply of water, power and labor. As expected Star-Kist and Van Camp are not drumming the bushes to support Bumble Bee's proposed development in American Samoa.

Longline fleet operation. Based on the number of boats operating out of American Samoa, the longline fishery appears to be extremely active. It was reported that approximately 300 boats were currently operating out of American Samoa.

PARAMOUNT. The PARAMOUNT arrived in Pago Pago on Saturday (23 Feb. 1974) with a tuna catch reported to be about 330 tons of small (4 to 6 lb.) skipjack. On the basis of information obtained from several sources, the skipjack were taken off New Zealand. This was the second catch offloaded by the PARAMOUNT; the first catch was offloaded in New Zealand and transshipped to Star-Kist canneries. For the second load Star-Kist must have decided that steaming from New Zealand to American Samoa was cheaper than paying the cost of freight. I received conflicting information on the success of fishing. From one source I was told that the total catch was

made in 10 days of fishing. Another source reported that the catch had been made in 38 days. Still a third report mentioned that 200 tons of skipjack were taken in 4 days of fishing. Whatever the case may be, fishing was considered extremely good. Conversations with one of the crew members indicated that he was satisfied with the financial arrangements. He and other crew members got a base amount in addition to an "incentive" clause which is tied in to the catch. A final note with regard to the PARAMOUNT. We received an unconfirmed report that the French Government in New Caledonia was negotiating with Star-Kist to have the PARAMOUNT carry out some trials in waters off New Caledonia after completion of the present trials (joint cooperative venture with the Government of New Zealand). October 1974 was reported to be the starting date.

Expert Committee on Tropical Skipjack Tuna

The meeting took place in Papeete, Tahiti, from 25 February-4 March 1974. The committee was appointed by the Committee on Fisheries of the South Pacific Commission. The purpose of the meeting was to establish cooperative research efforts and to develop a region-wide skipjack assessment program; review the skipjack fishing activities in the Pacific Ocean; develop a standard data format for collecting fisheries data, develop a method for data exchange and develop plans to conduct an extensive tagging program through the South Pacific.

Participants of this meeting included:

M. Rene Grandperrin, Centre ORSTOM, Noumea, New Caledonia
 Dr. Robert E. Kearney, Dept. of Agriculture, Stock and Fisheries, Papua New Guinea
 Dr. Stanley Swardloff, Dept. of Marine Resources, Pago Pago, American Samoa
 M. G. Loubens, Centre ORSTOM de Noumea, Noumea, New Caledonia
 M. F.X. Bard, Centre Oceanologique du Pacifique, Vaitao, Tahiti
 Dr. S. Comitini, Economic Research Center, University of Hawaii, Honolulu, Hawaii
 Mr. R.S. Shomura, NMFS, Honolulu, Hawaii

In general I felt the meeting was very successful. We were able to discuss in some detail the various topics relating to skipjack fishery development and research in the Pacific. We were also able to establish what was considered priority objectives. These included (1) the development of a basic catch and effort data to be collected by the several fisheries located throughout the Pacific area. The data sheets will follow the general format of the form used by the Government of Papua New Guinea. The plan is to have the Honolulu Laboratory produce these forms and send them to the Fisheries Officer of the South Pacific Commission. The forms will then be transmitted to countries and territories that have ongoing skipjack fisheries. Data collected by these countries and territories would then be transmitted back to the Honolulu Laboratory via

SPC, these data will be keypunched and placed on IBM cards. Final implementation depends on the approval of this arrangement by the various Governments and territories. The committee felt that by this method the membership of the South Pacific Commission would be able to centralize the collection of data and be in a position to evaluate the skipjack resources. (2) An agreement was reached to collect size frequency data from the several fisheries. (3) A general tagging project was developed; the plan to be submitted for consideration at the meeting of the Technical Committee on Fisheries to be held in July 1974. The Committee urged the establishment of extensive tagging experiments to determine migration, definition of subpopulations and to determine growth parameters. A recommendation made by the Committee was to urge Japan and other countries not affiliated with SPC to participate in the tagging program.

Miscellaneous information gathered during the trip.

1. Tahiti. Presently there are approximately 100 small vessels (called bonitiers) operating in Tahiti. These fast-moving boats utilize the Tahitian style of skipjack fishing which involved the use of pearl lures. On an annual basis the total catch probably does not exceed 2,000 tons. Currently plans are being developed to carry out trial pole-and-line fishing using live bait. I believe this program is being handled by CNEOX. Related to this subject, there appears to be some differences in opinion on the availability of baitfishes. Several of the local fishermen reported that baitfish was abundant in Tahiti, at least in sufficient quantities to support several small pole-and-line boats. Others state that baitfish is lacking.
2. CNEOX. I am not sure when CNEOX established a base in Tahiti. However, the French Government appears to be putting a considerable sum of money into this organization. They have started construction of a fair size laboratory at Vairao, Tahiti. The head of the CNEOX lab is M. de Chezeau. He was reported to be the powerhouse in the fisheries activity in Tahiti. The scientist responsible for the aquaculture and biology part of CNEOX is M. Alain Michel. M. Xavier Bard is the biologist engaged in the tuna research. The laboratory is still in the midst of a building phase. The French apparently believe in doing things on a realistic scale. As part of their construction program they built three extremely large concrete tanks which will be used in the pilot operation of culturing invertebrates and fishes. Presently they are working on the culture of Macrobrachium, several species of Penaeid shrimps and a local carangid fish species. The culture work will also include culturing species to be used as livebait for the skipjack pole-and-line fishing operation.

CNEOX hopes to have a boat (20 m length) in the near future. They plan to use this vessel to conduct some trials of livebait fishing for skipjack in French Polynesia. Thus, they expressed interest in a skipjack tagging program.

The Service de La Peche has started a program to collect catch and effort data. M. Bard also indicated that they have commenced with collecting of size frequency data of skipjack tuna.

One item of interest is that since the establishment of CNEOX in Tahiti a bit of rivalry has developed between CNEOX and the Service de La Peche. Xavier Bard, a biologist with CNEOX, appears to be trying his best to work cooperatively with La Peche.

3. Bumble Bee - Star-Kist joint venture. I had an opportunity to review the Bumble Bee - Star-Kist joint venture very briefly with representatives of Bumble Bee and Star-Kist. The joint venture is based on operating a transshipment point in Tahiti. The freezer unit is owned by Tahitian interests and is rented to the joint venture. I believe they mentioned something in the order of 50-60 boats being operated out of Tahiti. The major problem at this time is that fishing is so poor that nearly the entire fleet is currently in port.

4. Western Samoa. During my stopover in American Samoa I met Walter Paulo, who was the former skipper of the TOWNSEND CROMWELL. Mr. Paulo is currently employed by UNDP to work on a skipjack development project in Western Samoa. He was in American Samoa with the Fisheries Advisor to the Government of Western Samoa to obtain information and fishing supplies. Mr. Paulo has only been in Western Samoa for several weeks. He indicated that he was encountering innumerable problems involved with getting the boat in an operable condition. Also, he expects to encounter problems in training Western Samoans in the art of pole-and-line fishing and the related baitfishing activity. In listening to Mr. Paulo, it reminded me of the situation that American Samoa faced some four years ago.

Papua New Guinea.

Dr. Robert Kearney was one of the members of the Expert Committee. As a result I was able to obtain a considerable amount of information on the current status of the skipjack fishery based in Papua New Guinea. Dr. Kearney reported that last year's skipjack catch was approximately 28,000 metric tons. This is phenomenal when one considers the fact that the fishery started in 1970. This 28,000 ton catch was made by 30-35 Okinawan baitboats. Interestingly the fleet was on its way back to the Ryukyu Islands in late 1973 when they encountered large schools of skipjack north of Papua New Guinea. The boats turned around and return to Papua New Guinea and awaited the arrival of the skipjack schools in the fishing grounds. The skipjack did not disappoint them. Reports of 9 tons per day per boat were not uncommon. This heavy influx of skipjack in late 1973 was not expected on the basis of the previous two years' survey work. The fish were all small skipjack (5 or 6 pounds).

Dr. Kearney reported that they are collecting considerable amounts of catch and effort data of skipjack and also data on the catch of baitfish.

Collecting of these data has not proved to be much of a problem since the Government of Papua New Guinea insisted that the companies involved in the joint venture provide these types of data. The data presently are keypunched and put on computer cards for automatic data processing. Dr. Kearney's group recently completed an extensive tagging program. Some of their tag returns have indicated movements to the north and more recently to the southeast of the Papua New Guinea area.

Discussions with Dr. Kearney indicated that the continuance of this data collecting program was in doubt. The newly formed Government of Papua New Guinea will be taking over much of the activity presently sponsored by the Australian Government. Depending on their views, the Government of Papua New Guinea may not consider that these data are important. During the meeting of the Expert Committee we urged that some means be sought to continue the collection of these statistics.

5. British Solomon Islands. Dr. Kearney reported that the catch of skipjack by the joint venture operating out of British Solomons was approximately 7,600 tons landed by about 13 Okinawan boats.

6. New Caledonia. Presently New Caledonia has in operation two Tahiti-style skipjack boats operating in New Caledonian waters. The catch was reported to be about 30 tons per year. The French Government is hopeful of developing a skipjack fishery based in New Caledonia. Skipjack are known to occur in waters close to New Caledonia. The problem is to determine whether adequate supplies of baitfishes are available. The French Government hopes to obtain a 20-meter boat in the near future to conduct an extensive bait study. The French participants at the Expert Committee meeting requested assistance in developing their baitfish survey program. This was provided during the course of the meeting.

~~ESShore survey~~



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southwest Fisheries Center
 Honolulu and La Jolla Laboratories
 P. O. Box 3830
 Honolulu, Hawaii 96812

Date: March 21, 1974

Reply to Attn. of:

To: Fl42, Director, Honolulu Laboratory

From: Tamio Otsu, Chief, Tuna Assessment and Development Investigations

Subject: Trip Report: Trip to Japan, February 3-26, 1974

My itinerary on this trip to Japan was as follows:

- February 3 - 1300, departed Honolulu via PAA 1.
- 4 - 1650, arrived Tokyo.
- 5 - In Tokyo. Visited American Embassy, also met with Mr. K. Mimura, Japan Fisheries Agency, and Mr. S. Hikosaka, Sanyo Hydrographic Survey Co. 1450, departed for Shimizu, Shizuoka Prefecture.
- 6-10 - In Shimizu to attend the Tuna Conference and to meet with the staffs of the Far Seas Fisheries Research Laboratory and the Tokai University College of Marine Science and Technology.
- 11-12 - Visited Ito Branch of Shizuoka Prefectural Fisheries Experimental Station, and tuna bait cooperatives in Ajiro and Usami, Izu Archipelago, Shizuoka Prefecture.
- 13 - In Shimizu; met again with staffs of Far Seas Fisheries Research Laboratory and Tokai University.
- 14 - 0815, departed from Shizuoka RR Station for Shin-Osaka. Took All-Nippon Airlines, flight 181, for Oita Airport, Oita Prefecture. Arrived Oita 1345. Visited with staff of the Oita Prefectural Fisheries Department.
- 15 - Visited tuna bait area in Tsukumi, Oita Prefecture, and other fisheries offices.
- 16 - 0808, departed Beppu, Oita Prefecture by train, Nishi-Kyushu for Nagasaki City. Arrived 1350. Visited with officials of Nagasaki Prefectural Fisheries Department.

- February 17-19 - Visited tuna bait areas in Segawa; met with officials of bait cooperatives; and visited several fisheries offices in the vicinity of Nagasaki City and Sasebo City.
- 20 - Met with officials of the Sasebo Office of the Prefectural Fisheries Department. Departed from Nagasaki Prefecture's Omura Airport by All-Nippon Airways, flight 158, for Osaka at 1445. Continued on All-Nippon Airways, flight 34, from Osaka to Tokyo. Arrived Tokyo at 1815.
- 21-25 - In Tokyo to visit the Federation of Japan Tuna Fisheries Co-operative Associations (Nikkatsuren), the Japan Marine Fishery Resource Research Center (Kaiyo Suisan Shigen Kaihatsu Center), the Fishery Attaché at the American Embassy, the Iwatani Sangyo Company (sales agent for the ROBACK automatic fishing machines), Bumble Bee Seafoods office in Tokyo, Japan Fisheries Agency, and other fishery offices and individuals.
- 26 - 2230, departed Tokyo via PAA 2.
- 1030, arrived Honolulu.

This trip report is arranged by subject matter. The following subjects are included:

- A. Japanese Tuna Conference
- B. A Japanese scientist's views regarding the western Pacific skipjack tuna resource
- C. Japanese southern water skipjack tuna fishery, July-December 1973.
- D. Japanese skipjack tuna and baitfish surveys in tropical areas
- E. Purse seining for tunas
- F. Aggregating skipjack tuna
- G. Tuna baitfish fishery in Japan
- H. Baitfish transport
- I. ROBACK automatic fishing machines
- J. Use of live maaji (Trachurus japonicus, bigeye scad) as longline bait

- K. Results of regulation of the southern bluefin tuna fishery
 - L. Antarctic krill
 - M. Sardines
 - N. List of persons contacted during trip
- A. JAPANESE TUNA CONFERENCE

The Conference was held in Shimizu City at the Chuo-Kominkan (Civic Center). In attendance were about 200 persons representing the tuna industry (prefectural and national fisheries cooperatives), national and prefectural fisheries agencies, fisheries high schools, and universities. The Inter-American Tropical Tuna Commission was represented by Dr. Patrick Tomlinson who is working in Japan for a year on a cooperative project with scientists of the Far Seas Fisheries Research Laboratory. This year, Pat and I were the only foreigners attending the Conference. Pat spoke on the activities of the IATTC, while I spoke on our project to transport live bait (anchovy) from California to Hawaii to augment the supply of bait-fish for the Hawaiian skipjack tuna fishery.

The major problems facing the Japanese tuna industry this year are 1) fuel shortage and refueling problems for high-seas vessels, 2) "floating" yen, 3) increasing operating costs of fishing vessels, and 4) generally declining tuna longline catch rates and increasing competition from Korean and Taiwanese longline vessels. Another serious consideration was the upcoming Law of the Sea Conference and its implications. The mercury-in-tuna problem, not as serious as a few years back, is still a matter of concern and the Tokai Regional Fisheries Research Laboratory in Tokyo has been funded for intensive research on this matter. There was less discussion on the Japanese "skipjack tuna boom" this year but one speaker presented his views on the skipjack tuna resources of the western Pacific and the need for Japan to reexamine her skipjack tuna fishery development policy. This matter is covered in another section (B) of this trip report.

Although official Japanese statistics may contradict my observation, I noticed a dramatic decrease in cigarette smoking in the conference room this year. Last year I commented on the "smoke-filled" atmosphere of the conference room. On the surface, it appears that many people had "kicked" the habit during the year. I, incidentally, continued to pollute the air.

B. A JAPANESE SCIENTIST'S VIEWS REGARDING THE WESTERN PACIFIC SKIPJACK TUNA RESOURCE

Dr. Kohei Kasahara, leader of the skipjack tuna studies at the Tohoku Regional Fisheries Research Laboratory presented a paper at the Tuna Conference expounding his views that the skipjack tuna resource of the western Pacific (Japanese coastal waters as well as the Japanese southern water fishery) is already being fished at close to the maximum level. He stated that the maximum catch, in view of the declining trend in catch rates and increasing trip lengths, should be around 180,000 metric tons of skipjack tuna. He also stated that the maximum fishing effort (no. of days of fishing) should not exceed 110,000 days, and that the present effort is already around 90,000 days. Dr. Kasahara mentioned that the catch of skipjack tuna for the last 2 years has exceeded 200,000 metric tons.

Other scientists mildly disagreed with Dr. Kasahara's statements, although agreeing in general that there should not be any great increase in fishing effort in Japanese coastal waters. As for the southern water fishery, the feeling was that new fishing grounds should be sought, and that the catches can still be increased rather significantly.

Dr. Kasahara made it clear that his estimates were tentative and needed further evaluation, but that the Japanese should reexamine their plans to push skipjack tuna fishery development under the present policy.

C. JAPANESE SOUTHERN WATER SKIPJACK TUNA FISHERY, JULY-DECEMBER 1973 (SEE CHARTS, ALSO).¹

July

Because albacore fishing continued over a relatively long period extending into the latter part of July, the start of large-scale skipjack tuna fishing in the Mariana area was delayed this year until toward the end of July. Three vessels that had moved south in early July fished between lat. 15°-16°N, long. 145°-146°E and took about 110-150 tons per trip (maximum day's catch of 30-35 tons per vessel), thus showing a good start for the season. More vessels entered the fishery in late July and the fishing grounds spread from waters east of the Marianas to around Minami Tori-shima and Wake Island.

¹From preliminary data provided by Dr. K. Kasahara, Tohoku Regional Fisheries Research Laboratory, Shiogama-shi, Miyagi-ken, Japan.

The waters extending from the Marianas to Minami Tori-shima and Wake Island were relatively cool last year (27°-28°C) and fishing was unusually poor. However, the surface temperatures reached 29°-30°C this year, and fishing was quite good.

Near Hahajima in the Bonins, catches of about 30 tons per day per vessel were experienced, and for a brief time there was a concentration of the smaller skipjack tuna vessels from Kochi Prefecture in this area.

About a month earlier than usual, a number of vessels fished in the vicinity of Truk (lat. 7°N, long. 153°E) and catches amounted to about 120 tons per trip (maximum day's catch of about 20 tons).

The sizes of fish taken were as follows:

At lat. 16°N, long. 145°E: 4% above 6 kg, 4% between 4.5 and 5.9 kg, 70% between 2.5 and 4.4 kg, 16% between 1.5 and 2.4 kg, and 5% below 1.4 kg.

At lat. 19°-21°N, long. 150°-154°E: 7.2% above 9 kg, 12.7% between 6.0 and 8.9 kg, 6.6% between 4.5 and 5.9 kg, 62% between 2.5 and 4.4 kg, 11% between 1.5 and 2.4 kg, and 0.5% under 1.4 kg.

In waters near Truk, 25% of the fish were larger than 4.5 kg, 95% between 2.5 and 4.4 kg, and 2.5% were between 1.5 and 2.4 kg.

In July, 14 vessels entered the port of Yaizu to unload 1,088 metric tons of fish from southern waters. There were also 12 vessels returning with 280 tons of fish from the Bonins.

August

In the first half of August the grounds extending from the Marianas to Wake Island remained active. At lat. 20°-22°N, long. 160°-171°E, good fishing took place on large skipjack tuna of 9-13 kg. In the latter half of the month, these grounds gradually weakened and moved southward, and a broad fishing ground developed along lat. 5°-7°N, long. 144°-172°E. In the areas lat. 5°-7°N, long. 150°-153°E and lat. 5°-7°N, long. 169°-172°E, there were a few catches of as much as 40-60 tons per day, and there were several vessels making capacity loads.

A few vessels headed toward the Hawaiian Islands but catches there were very poor this year.

During August, 39 vessels unloaded 2,454 metric tons (including 26.5 tons of small yellowfin and bigeye tunas) of southern water skipjack tuna in Yaizu port. The catch per vessel amounted to 63 metric tons.

September

The fishing grounds in the vicinity of the Marianas were so scattered that virtually all of the vessels shifted to waters south of lat. 10°N . Initially, a fishing ground formed south of Grimes Island at lat. $3^{\circ}\text{--}7^{\circ}\text{N}$, long. $143^{\circ}\text{--}146^{\circ}\text{E}$. Soon thereafter, vessels were catching 30-50 tons per day at lat. $2^{\circ}\text{--}4^{\circ}\text{N}$, long. $154^{\circ}\text{--}158^{\circ}\text{E}$, and north of Ponape at lat. $7^{\circ}\text{--}9^{\circ}\text{N}$, long. $156^{\circ}\text{--}160^{\circ}\text{E}$. By midmonth, many vessels were concentrating in these latter grounds and were making consistently better catches than in recent years.

As for fish sizes, 77% of the catch consisted of 3-4 kg fish and 17% of 4.5-5.0 kg fish. Unlike last year, there were virtually no small fish of 1-2 kg size. There were approximately 40 vessels, mostly from Shizuoka Prefecture, fishing these grounds.

Vessels from Mie Prefecture were fishing waters east of long. 160°E extending into the Marshall Islands. Good fishing which began late in August was continuing, and there were many catches of up to 50-60 tons per day. About 40% of the vessels were realizing capacity loads. Since the fishing grounds were located somewhat to the north at lat. $5^{\circ}\text{--}12^{\circ}\text{N}$, the fish taken were relatively larger: 60% of the fish were 3-4.5 kg fish, 27% were 4.5-5.5 kg fish, and 5.6% were 6-7 kg fish. There were an estimated 60-70 vessels fishing in this area.

The waters around the Gilbert Islands, which last year provided good fishing, proved poor this year with only a few scattered schools of fish. This may have been due to water temperatures of $26^{\circ}\text{--}27^{\circ}\text{C}$, $2.5^{\circ}\text{--}3.5^{\circ}\text{C}$ lower than last year.

In September, 61 vessels returned to Yaizu to unload 8,120 tons (including 173 tons of small yellowfin and bigeye tunas) of southern water skipjack tuna. The catch per vessel averaged 133 tons. In addition, eight vessels unloaded 99.8 tons of fish from the Bonin area.

October

Continuing from September, fishing by Shizuoka Prefecture vessels was good at 1) lat. $2^{\circ}\text{--}8^{\circ}\text{N}$, long. $150^{\circ}\text{--}160^{\circ}\text{E}$, and 2) by Mie Prefecture vessels at lat. $3^{\circ}\text{--}12^{\circ}\text{N}$, long. $162^{\circ}\text{--}175^{\circ}\text{E}$. At the former ground there was a mixture of good and poor fishing in an east-west direction. The fish sizes were about the same as in September, with 87.8% of the catch consisting of 2.5 kg fish and 8.8% of 4.5 kg fish. The latter ground encompassed a broad area from north to south. North of lat. 8°N most of the fish were larger than 5 kg, while to the south, fish of around 2.5 kg predominated.

In the area from lat. 2° - 3° N, long. 153° - 154° E to lat. 3° - 4° N, long. 165° - 167° E, there was a zone of discolored water. Numerous reports of "large, thick schools" were received from the area but apparently these schools responded poorly to chumming. The Gilbert Islands area continued to be bathed by low temperature water (26° - 27° C) and fishing remained poor.

In October, 83 vessels unloaded 10,874.8 tons (including 92.3 tons of small yellowfin tuna) of southern water skipjack tuna at Yaizu port. The catch per vessel was 131 tons. This month's landings established a new record for southern water skipjack tuna landings.

November

Other than for a brief period in early November when fishing was rather good in waters west of Truk, fishing conditions were worse than in previous months. After mid-November, considerable fishing took place in waters west of long. 150° E (there were practically no vessels remaining in waters east of long. 160° E) and 130-140 vessels from Mie, Shizuoka, Ibaragi, and Kagoshima Prefectures concentrated in the area lat. 6° N- 2° S, long. 142° - 149° E. At lat. 1° N- 2° S, long. 145° - 147° E, some catches of 30-60 tons per day continued for a while, but fishing conditions were extremely variable, and the average day's catch amounted to 6-8 tons.

In equatorial waters (lat. 2° N- 2° S, long. 145° - 150° E) 7.4% of the fish were larger than 4.5 kg, 85.6% were from 2.5 to 4.4 kg, 6.8% from 1.5 to 2.4 kg, and 0.2% were smaller than 1.4 kg. At lat. 5° - 9° N, long. 144° - 155° E, 1.4% were larger than 6 kg, 15.3% from 4.5 to 5.9 kg, 75.4% from 2.5 to 4.4 kg, 6.7% from 1.5 to 2.4 kg, and 1.2% were smaller than 1.4 kg.

In November, 82 vessels unloaded 9,650.7 tons (118 tons per vessel) of southern water skipjack tuna in Yaizu port. In addition, two vessels that operated the previous month landed 120.9 tons and seven vessels landed 221.9 tons of skipjack tuna from the Mariana Islands area. There were 14.9 tons of small yellowfin tuna for a grand total of 9,879.2 tons.

December

The fishing ground that developed just to the north of Manus (lat. 1° N- 2° S, long. 145° - 149° E) in mid-November continued to be quite good, with a maximum day's catch of 50 tons and an average catch of 8-12 tons per day. About 50 vessels from Mie and Shizuoka Prefectures fished this area. In early December, the schools were either 1) seen at the surface as jumpers, 2) associated with birds, or 3) feeding on natural prey. However, towards the end of the month, many schools were also found with floating logs, and there

was an increase of small skipjack tuna (1.5-2.5 kg) as well as small yellowfin and bigeye tunas in the catches.

The fish sizes in early December were: 5.3%, 4.5-5.0 kg; 89.5%, 3.0-3.5 kg; and 5.2%, 1.8-2.2 kg. In late December, when log-associated schools were also encountered, the size composition changed to 5.8%, 4.5-5.0 kg fish; 82.2%, 3.0-3.5 kg fish; and 12%, 1.8-2.2 kg fish.

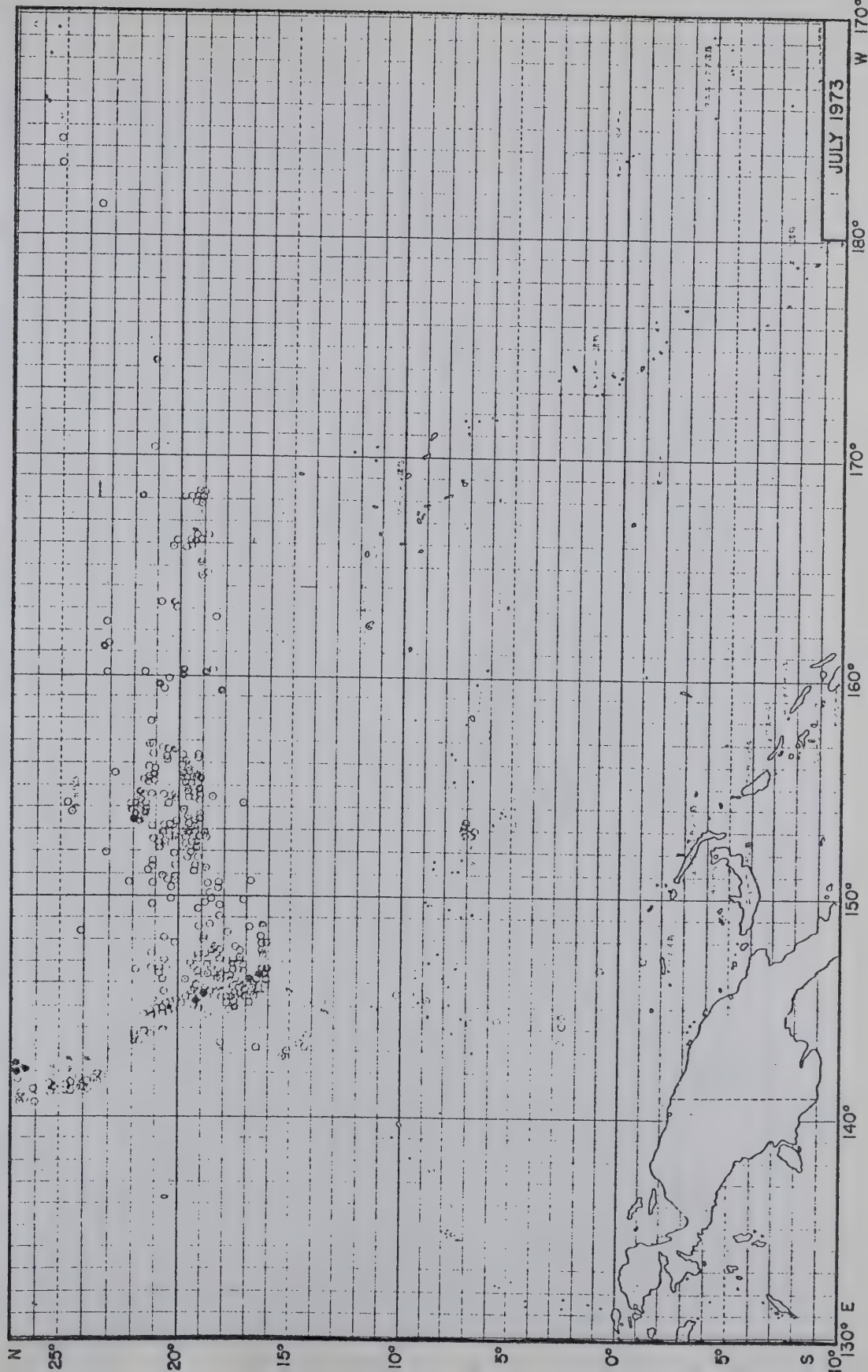
At the same time, moderately good fishing was also seen in waters to the south of the band extending from Palau to Yap, with average catches of 4-5 tons per day.

Also, four or five purse seiners operated in waters around lat. 3°N, long. 134°-136°E, fishing log-associated schools of tuna. They caught 15-50 tons per set of 1.5-4.5 kg skipjack tuna with an admixture of small yellowfin and bigeye tunas.

This season's results of purse seining in the Coral Sea were as follows:

In late October, skipjack tuna was the principal species taken, with catches of 2-20 tons per purse seine set (1.5-5.0 kg skipjack tuna either associated with shark or with floating logs; surface temperature 26.8°-27.4°C). Entering November, the catches of shark-associated yellowfin and bigeye tunas began to increase. The maximum catch per set was 100 tons, and other catches of 10, 27, 40, and 60 tons per set were experienced. This year's fishing season for yellowfin and bigeye tunas extended from November 1 through 12, but since weather conditions did not permit setting the net between November 5 and 11, fishing was possible only on 5 days. Six purse seiners caught an estimated 400 tons of small yellowfin and bigeye tunas during the period. During this season chopped fish were chummed from a boat to aggregate fish before seining. Apparently this method produced some good results.

In December, 99 vessels unloaded 10,556 tons of southern water skipjack tuna in Yaizu port, for a catch per vessel of 106.6 tons. Two purse seiners unloaded an estimated 300 tons of skipjack tuna, and 200 tons of small yellowfin and bigeye tunas.



JULY 1973

180°

170°

160°

150°

140°

130° E

S

0°

5°

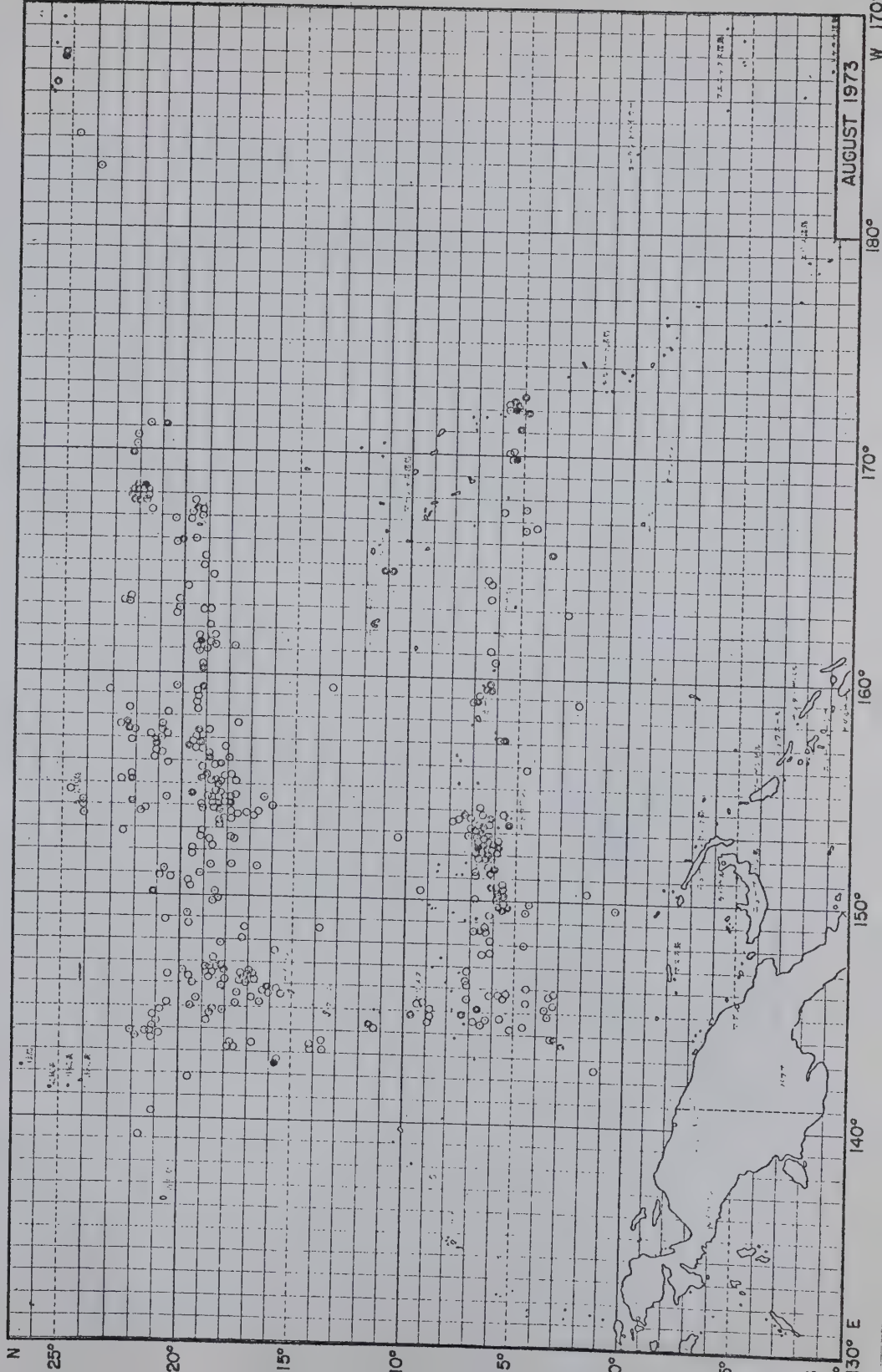
10°

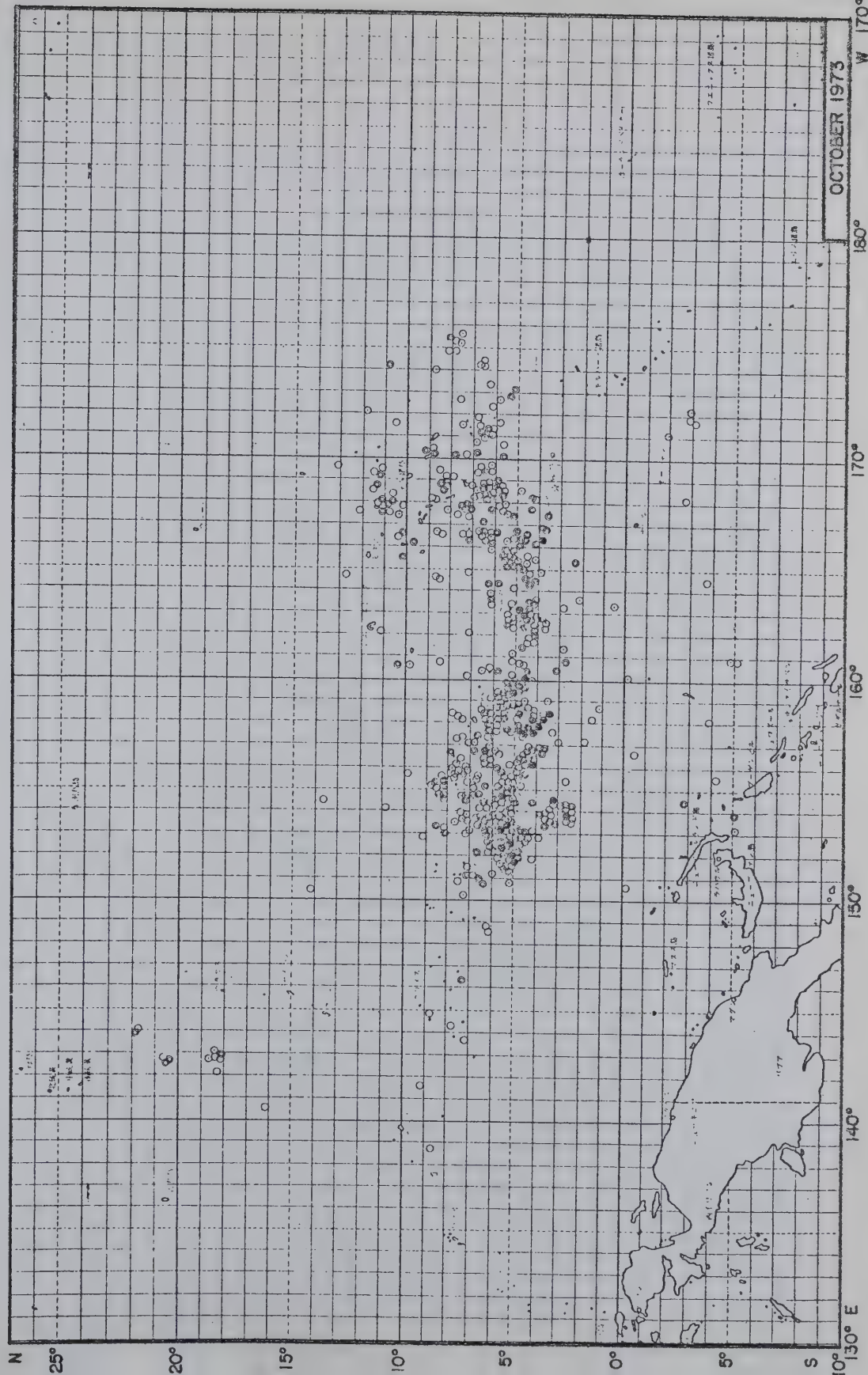
15°

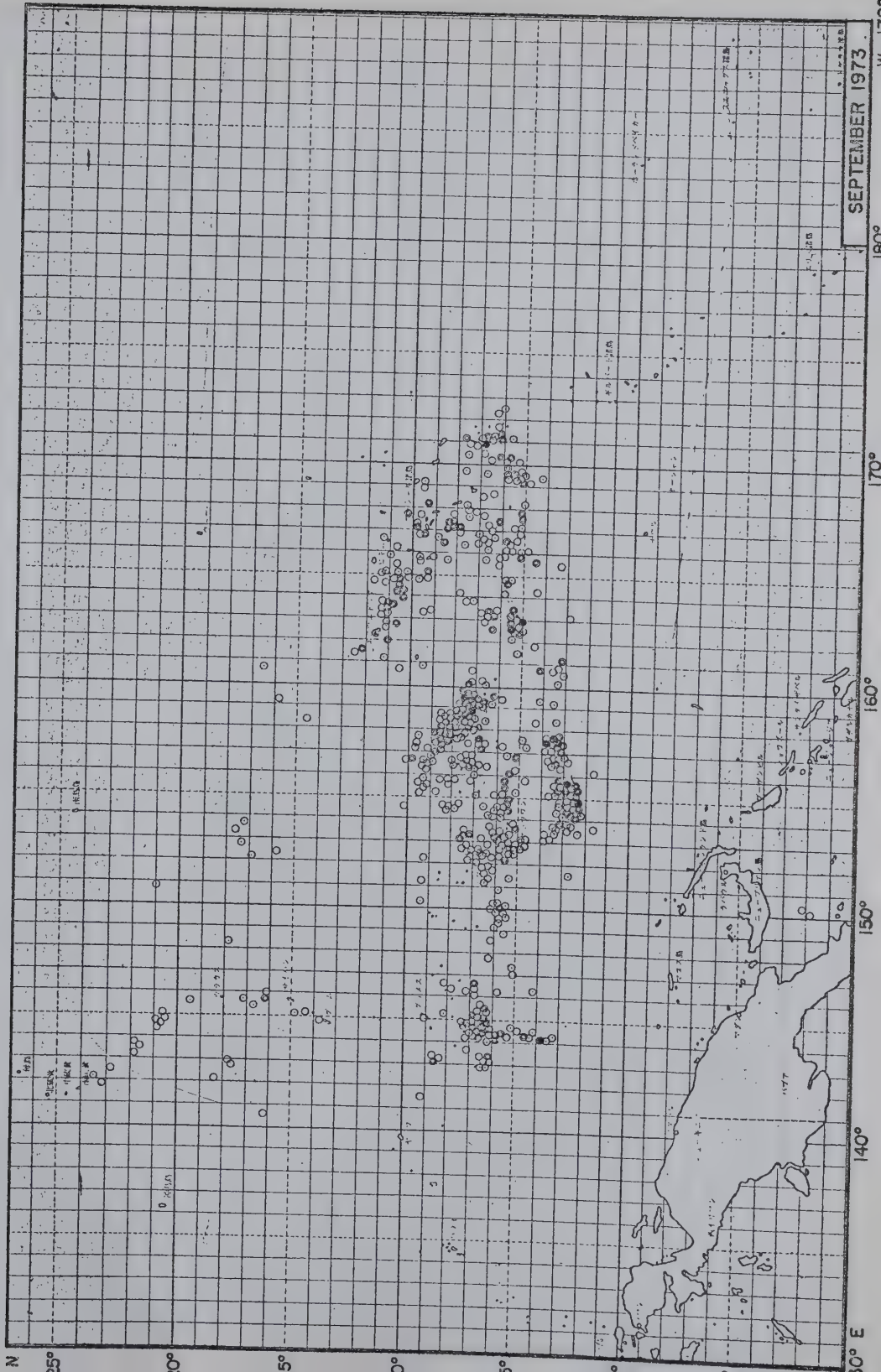
20°

25°

N







SEPTEMBER 1973

180°

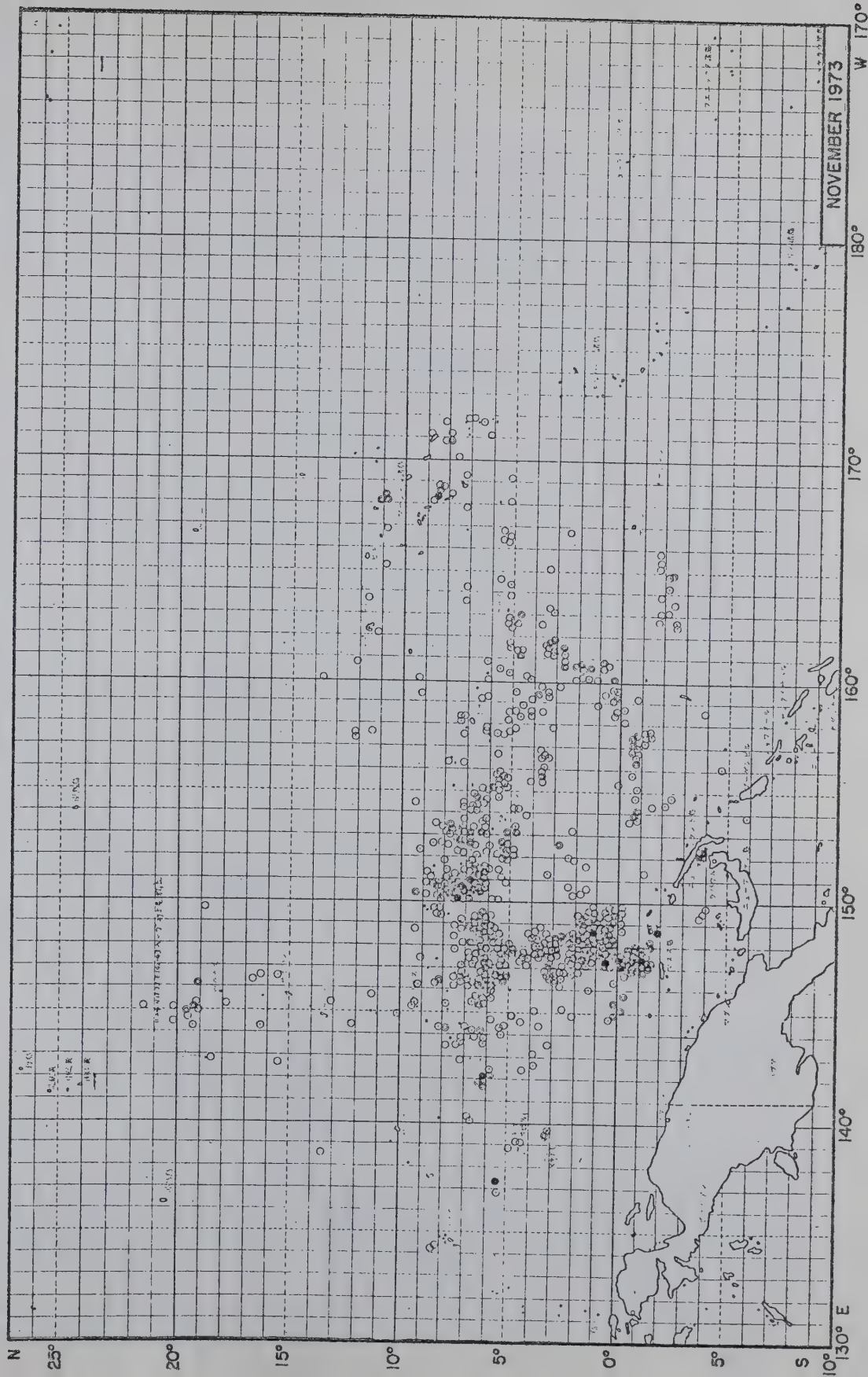
170°

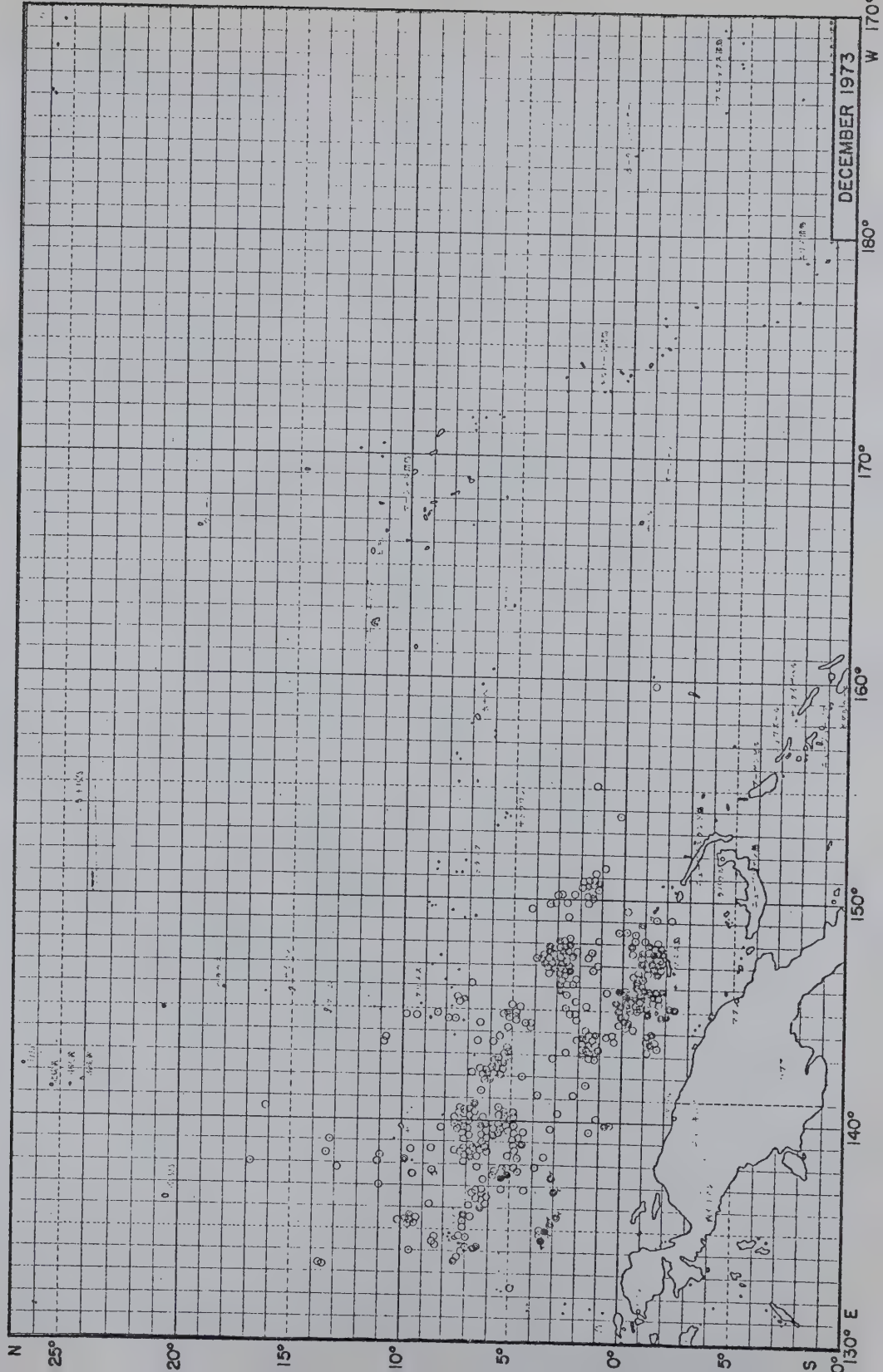
160°

150°

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130° E





D. JAPANESE SKIPJACK TUNA AND BAITFISH SURVEYS IN TROPICAL AREAS

Skipjack tuna bait surveys have been conducted by the Japan Marine Fishery Resource Research Center continuously since 1971. In 1973 a 192-ton vessel was chartered to conduct surveys in Tonga, New Caledonia and at Wallis Island (northwest of Samoa).

The bait survey in New Caledonia, using lift nets to capture bait-fish at night, resulted in catches of 50-100 buckets a day. Baiting was done in waters 0.5-1.5 mile offshore. Skipjack tuna fishing this year was not as good as last year since, in general, the schools responded poorly to chumming.

At the request of the French, a very brief (1 week) survey was conducted at Wallis Island. This little island has a large lagoon with freshwater runoff from a stream. The surrounding reef makes baiting difficult. Here, only 30-40 buckets of bait were taken, and skipjack tuna fishing resulted in catches of 4-5 tons per day. In general, it was found that skipjack tuna are fairly abundant, but that bait supply is inadequate for any significant fishery development, although further studies are needed.

The series of surveys in Tonga revealed that among the 200-300 islets scattered throughout the archipelago, the northernmost island seems most promising as far as bait is concerned. Surveys were conducted to depths of 30 m. Using beach seines, 20-30 buckets of baitfish were captured in a set. Heavy mortality was encountered in the bait species taken.

The conclusions drawn by the Center are that New Caledonia has definite possibilities for the development of a pole-and-line skipjack tuna fishery. The situation at Wallis Island is not yet clear, but there is little likelihood of the development of a fishery in Tonga. At the present time, Japan is studying the results to see whether or not to propose a joint venture with the Government of New Caledonia.

Center officials indicated that they have now concluded skipjack tuna and live-bait surveys in the Tonga, New Caledonia, and Wallis Island areas, and plan on beginning studies in Micronesia (Truk and Ponape were mentioned as possibilities).

E. PURSE SEINING FOR TUNAS

The Japan Marine Fishery Resource Research Center is continuing to charter purse seiners to conduct fishing experiments in tropical waters. On September 30, 1973 the chartered vessel No. 55 Hakuryu Maru departed Japan to operate in waters between NW Australia and Indonesia (Timor Sea). Purse seining requires relatively calm seas

(wind force of 3 or less). The vessel apparently encountered rough seas during most of the survey period (September-January). Although there were areas of relatively shallow thermocline, inclement weather worked against them. Furthermore, the vessel encountered few drifting logs, and fish schools were very scarce. The results have been most disappointing: as of the end of January only 30 tons of fish had been taken.

In spite of this some Japanese observers feel that purse seining for skipjack tuna is feasible in tropical waters. They believe that the state of the art has reached a point where commercial application can be made. They have been using Japanese-type purse seines (deeper and larger than U.S.-type seines) and feel that by setting around a log-associated school either early in the morning or towards twilight, they can catch a fair amount of fish. (In another part of this report, under Japanese Southern Water Skipjack Tuna Fishery for December 1973, is a report on commercial purse seining results in tropical waters.)

F. AGGREGATING SKIPJACK TUNA

The Far Seas Fisheries Research Laboratory began experimenting with artificial "drift logs" about 2 years ago to see if they could aggregate skipjack tuna. These "logs" are essentially three 2-m square rafts, joined together by ropes 100 m long and set adrift. One raft was strung with palm fronds, and one with 10-m long ropes. One was set adrift with nothing on the bottom.

Most of the experiments to date have been conducted in the vicinity of Papua New Guinea. In the first experiment in 1972, a large school of skipjack tuna about 30 cm long was seen very close to the rafts on the first morning of the drift. However, the school had disappeared by the second morning. Some skipjack tuna were seen jumping during the day and evening about 70 or 80 m from the drifting rafts. The results were inconclusive.

In 1973, a skipjack tuna school was sighted before the rafts were set adrift. However, the school gave no discernible response. No skipjack tuna appeared in the vicinity of the rafts during the first 2 days. A few skipjack tuna schools appeared after the third day, but they continued to move on and in no case did they appear to be attracted to the rafts. After the sixth day of the drift however, a large skipjack tuna school approached the rafts and remained with them. In this 1973 experiment, the fish were near the rafts from about 0600 to around 1300, apparently attracted to them. Unfortunately, it was not possible to continue the experiment.

It was also reported that the No. 55 Hakuryu Maru, the 500-ton purse seine vessel under charter to the Japan Marine Fishery Resource Research Center, had conducted experiments similar to those using rafts to aggregate skipjack tuna for purse seining in the Coral Sea. The vessel reportedly set adrift two 55-gallon oil drums, lashed together and provided with light and radio buoy, and followed them for several days. After 6 days, a school of small yellowfin tuna and some skipjack tuna gathered in the vicinity, and the vessel was able to make a set that resulted in 20 tons of fish. This was the only catch of tunas made by the vessel in the Coral Sea where the sea and weather conditions are generally unfavorable for purse seining. Another report on fish aggregation described an experiment by a Taiyo Fishing Company purse seiner. This vessel set adrift a small boat which had ropes hanging down the sides. The seiner followed the boat for 3 days without seeing any tunas. After 3 days, it lost sight of the boat. The Australian Coast Guard found the boat, identified it, and summoned the purse seiner to Brisbane. The Taiyo Fishing Company decided then and there to discontinue this type of experiment.

In general, the Japanese scientists concluded that it is quite possible to aggregate skipjack tuna by means of drifting devices. Using underwater television, they found that several species of small fish were first attracted to the rafts, and it generally took about a week before skipjack tuna would gather in the vicinity. Skipjack tuna were generally seen from around noon to evening, rarely during the morning hours.

The Honolulu Laboratory is also considering conducting experiments to aggregate skipjack tuna either for purse seining or for pole-and-line fishing.

G. TUNA BAITFISH FISHERY IN JAPAN

According to a report recently published by Mr. Shoichi Masuda, Director, Federation of Japan Tuna Fisheries Co-operative Associations, the total annual catch of anchovy (Engraulis japonica) in Japan is about 230,000-250,000 metric tons, and of this amount, roughly 10% is used as tuna live bait. Japanese statistics show that in 1970, 21,300 metric tons of anchovy were used as live bait, and in 1971, 20,800 metric tons. Anchovy comprises roughly 97% of the total live bait used in Japan. Since the total 1970 tuna catch by the Japanese skipjack tuna fishery amounted to 236,626 metric tons (skipjack tuna and all other species of tuna taken by the live-bait method), the catch of tuna per ton of live bait was roughly 11.1 metric tons.

Table 1 shows some bait data from the Japanese skipjack tuna fishery for 1970. The data give an idea of the live-bait requirements of skipjack tuna vessels of different sizes, and of the value of the fishery that provides live bait to the fishing vessels. It should be noted that all of the conversions of value have been standardized to the present conversion rate of 300 yen per US\$1.

One of my missions on this trip to Japan was to visit several of the important tuna baitfish fishery areas. Through the cooperation of the staff of the Far Seas Fisheries Research Laboratory and the Shizuoka Prefectural Fisheries Experimental Station, an itinerary was arranged for me to visit bait fishery areas in Shizuoka Prefecture (Ajiro, Usami), Oita Prefecture (Tsukumi), and in Nagasaki Prefecture (Segawa). These areas are representative of the Kanto and Kyushu baiting areas (central and southwestern Japan, respectively).

In each area visited, the bait receivers (ikesu) were situated in well-sheltered bays with a good circulation of clean "oceanic" water. Fishing for bait was generally done by the bait cooperatives in the various areas. Since there were considerable differences in the mode of operation from place to place, each baiting area will be described separately.

1. Shizuoka Prefecture

In Shizuoka Prefecture, I visited the bait cooperatives in Ajiro and Usami, two of the several important baiting areas in the Prefecture. Shizuoka Prefecture is the leading skipjack tuna fishing prefecture in Japan, and there is considerable demand for live bait. Since the prefectural baiting areas periodically experience bait shortages, about three bait-transport vessels are now in operation transporting bait purchased from Kyushu baiting areas to Shizuoka Prefecture.

Most of the anchovy in Shizuoka Prefecture are being taken by purse seine, either a one-boat or two-boat operation. In addition to the seiners, a baiting unit includes a fish-finder vessel, a small vessel which scouts for anchovy, and a "tugboat" to tow the bait receivers to and from the fishing grounds. The fleet usually leaves for the fishing ground at around 3 p.m. and fishes at night. At the Usami bait cooperative, it was reported that 80-85 men were presently involved in the operation. The officials indicated that they could operate with as few as 60 men but that the cooperative was obligated to keep all of the men employed.

It is essentially a "family" operation, and these people have worked together for many years. The fishing grounds are 3-6 miles from the village, and the fishing area is limited to them by regulations.

Table 1.--Japanese distant-water skipjack tuna fishery data on amount of bait carried per vessel, by vessel size, and amount paid per bucket of bait, shown by quarters of the year and by area of bait purchase, for the year 1970. (Data from Federation of Japan Tuna Fisheries Co-operative Associations.)

Vessel tonnage	Quarter	Bait area								
		Sanriku			Kanto			Shikoku-Kyushu		
		No. of trips	No. of buckets	Price per bucket	No. of trips	No. of buckets	Price per bucket	No. of trips	No. of buckets	Price per bucket
70-135	Jan.-Mar.	--	--	--	9	153	\$6.58	4	120	\$ 8.64
	Apr.-June	2	97	\$10.00	58	207	6.51	1	81	9.01
	July-Sep.	14	114	9.36	34	202	5.71	--	101*	8.75*
	Oct.-Dec.	3	124	9.95	14	206	5.52	--	101*	8.75*
135-165	Jan.-Mar.	--	--	--	1	260	5.50	4	216	5.52
	Apr.-June	--	97*	10.00*	9	297	5.38	2	255	4.71
	July-Sep.	1	103	10.97	9	279	5.50	--	236*	5.07*
	Oct.-Dec.	--	124*	9.95*	4	278	5.47	--	236*	5.07*
165-195	Jan.-Mar.	2	180	8.00	21	313*	5.11*	61	188	7.73
	Apr.-June	1	194	9.33	136	349	5.89	27	190	7.44
	July-Sep.	39	197	9.93	101	364	5.56	11	207	7.05
	Oct.-Dec.	16	177	10.36	28	323	5.80	28	207	8.65
195-225	Jan.-Mar.	--	--	--	--	313	5.11	3	173	8.34
	Apr.-June	--	194*	9.33	9	296	7.11	--	190*	7.44
	July-Sep.	5	171	10.06	6	382	5.63	--	207*	7.05*
	Oct.-Dec.	1	187	9.32	1	325	5.50	1	180	10.00
225-255	Jan.-Mar.	--	--	--	1	478	5.00	38	269	6.64
	Apr.-June	--	194*	9.33*	62	388	6.20	13	223	7.43
	July-Sep.	19	267	9.51	43	417	5.60	1	362	5.52
	Oct.-Dec.	6	232	9.99	7	447	6.19	12	285	7.67
255-285	Jan.-Mar.	--	--	--	1	460	5.50	10	263	6.84
	Apr.-June	--	194*	9.33	17	455	6.87	5	232	6.91
	July-Sep.	2	300	11.00	12	484	5.66	4	256	6.71
	Oct.-Dec.	--	232*	9.99	1	455	5.50	6	203	9.38
> 285	Jan.-Mar.	--	--	--	1	475	5.49	8	231	8.18
	Apr.-June	--	194*	9.33	15	496	5.65	3	241	8.34
	July-Sep.	3	274	10.23	12	529	5.51	1	229	7.28
	Oct.-Dec.	1	438	8.50	7	491	5.49	1	212	10.00

Notes: Data above based on records of 58 vessels sampled.

* denotes estimates...no actual data available.

No. of buckets = the number of buckets purchased by a vessel for a single trip.

Price per bucket = amount derived through conversion of 300¥ to US\$1.

Sanriku - north of Ibaragi Prefecture; Kanto - between Chiba and Wakayama Prefectures; Shikoku-Kyushu - prefectures in Shikoku and Kyushu Islands.

According to a Mie Prefecture Hamajima Fisheries Experimental Station report, buckets are measured in 14.4-liter buckets but amount of fish varies, e.g., in Kanto area, a bucket is estimated to contain about 3-4 kg of anchovy, and the bait seller determines amount. In the Kyushu and Tohoku areas, a bucket contains 6-7 kg of fish, and the buyer determines amount.

a. Bait receivers (ikesu)

The bait receiver frames are constructed of either bamboo (three pieces lashed together), or of wood (either cypress or cedar). The bamboo or wooden frames are square, hexagonal or octagonal. It is believed that the ideal bait receiver is one that is circular, and the octagonal frame approaches this ideal most closely. The bamboo frames are 6-11 m (20-35 feet) to a side, while the wooden frames are 4.7-6.5 m (15-21 feet). Netting is suspended from the surface frame to form the bait receiver, usually 3.8-5.6 m (12-18 feet) in depth.

Typically, a 4-m (13-foot) square bait receiver, 3.8 m (12 feet) in depth, holds approximately 120 buckets (3-5 kg per bucket) of bait; a 4.7-m (15-foot) square receiver, 3.8 m (12 feet) in depth, holds 200 buckets; a 6.6-m (21-foot) hexagonal bait receiver, 5.6 m (18 feet) deep, holds about 700 buckets of bait. The amount of anchovy held in these receivers also depends greatly on the size of the fish.

The netting of the bait receivers is either anchored to the floor of the bay with a long pole passing through rings at each corner or in some cases, is provided with a ring of lead weights (totaling about 50 kg (110 pounds)) near the bottom of the net.

b. Fishing operation and transfer of bait

When the fish-finder vessel locates a school of anchovy, the school is surrounded with a purse seine (either a one-boat or two-boat operation). The seine is pursed until the fish are concentrated loosely in the bunt of the net. At this point, a portion of the netting from the bait receiver is removed from the frame and placed under the seine; the anchovy are then allowed to swim into the bait receiver. After the fishing operation is completed, a string of receivers is towed back to the bay by the tugboat at a speed of about 1 knot. In Usami, the maximum day's catch by a fishing unit has been 45 receivers of bait. The usual catch is about 10-15 receivers per operation.

c. Bait rearing

The best months for fishing anchovy for live bait is during the winter, from November to January. Anchovy caught in November-December are often reared in the bait receivers until March when they are sold to fishing vessels. The anchovy generally suffer some mortality immediately after

capture. The mortality depends upon temperature of the water, handling, size of fish, etc. Temperature appears to be a very important factor. In summer the catch is generally of small 0-age anchovy and the mortality is very high. Survival may be only 30%-35%, and at best 50%. With lower temperatures, the 1- to 2-year old anchovy taken during the winter months generally do quite well. The survival rate is about 70%.

Mortality is highest during the first 3 days after capture, and the survivors generally do well after that. There are occasional instances in which there is mass mortality from sudden changes in temperature or from the runoff caused by heavy rains. There is also an occasional problem, especially around June, with red tide.

The fish are fed daily on a ration of commercial pellets or minced fish flesh at a rate of about 3% of body weight. The amount of food fed is dependent upon the time of year, with more food given during the warmer months. Officials reported that anchovy can be held in the receivers without feeding for about a week.

2. Oita Prefecture (Tsukumi Bay)

At Oita Prefecture I visited the bait cooperative at Tsukumi. It is one of the important bait areas in Kyushu, and is operated strictly for vessels from outside prefectures since Oita Prefecture does not have a skipjack tuna fishery of its own. Vessels from Shizuoka, Kochi, and Miyazaki Prefectures, among others, come here to purchase their bait.

According to Prefectural officials, about 15,000 tons of anchovy are taken each year, and about 10% is used as live bait. In Tsukumi, the estimated volume of a bucket of bait is 7-10 kg of baitfish. One bucket of bait is sold for 4,000 yen (\$13.33).

a. Bait receivers (ikesu)

The common types of bait receivers in use have either bamboo or wooden frames similar to those of Shizuoka Prefecture. The one I visited in Tsukumi was a very large octagonal bait receiver, 8-10 m (26-33 feet) to a side. The depth of the netting was about 10 m (33 feet) and the bait cooperative official reported it to have a volume of up to 1,000 buckets of anchovy (7-10 kg per bucket). Many of the bait receivers were smaller, with much smaller bait-holding capacities.

b. Baiting fleet

A baiting fleet in Tsukumi consists of two 7-ton catcher boats (seiners) or a one-boat seiner, a 2-ton lightboat, a transport, and a tugboat. The fishing is done at night with the lightboat attracting the anchovy. The purse seine is typically about 300 m (960 feet) in length, but varies greatly from fleet to fleet. The fishing method and the method of transferring bait from seine to receiver are similar to methods used in Shizuoka Prefecture.

c. Transferring anchovy from net to receiver

When the seine is pursed to a point where the fish are loosely congregated in the bunt of the net, the float of that portion of the net is lifted over one portion of the bait receiver. That part of the bait receiver is forced downward and submerged to a depth of about 70 cm (28 inches). The anchovy are then allowed to swim into the bait receiver.

Another technique is to remove one portion of the bait-receiver net from the frame, and to place the floats of the bunt portion of the seine over it. The bait-receiver net is then forced downward, allowing the anchovy to swim from the seine into the receiver. Sometimes a light is used to attract the anchovy from the seine into the receiver. When a bait transfer is in progress, there must be absolute quiet on board the vessels so as not to frighten the fish.

d. Bait rearing

A thousand buckets of bait can be caught in one morning in a single set. Baitfish are reared for at least 20 days in winter before they are ready to be sold. The bait cooperatives in every locality stressed the fact that they want to sell only the best bait possible since their business is dependent on their reputation.

More specifically, it was considered here that during the winter when the temperature is low, at least 15-20 days is required for rearing; during the spring and summer, at higher temperatures, a rearing period of at least 10 days is required. Feeding of baitfish generally commences after about a week of rearing. During the winter, the anchovy were fed 1%-2% of body weight; this ratio increased with temperature.

e. Bait mortality

Careful handling is necessary in order to avoid heavy mortality. After capture, it was reported that there is usually about a 25% mortality after the first day, 7% on the second day, and about 1% the third day. Following the third day, there is usually no more than about 1% mortality. This mortality rate generally holds during the winter months. In summer, it is considerably higher.

f. Towing of bait receivers

In towing the bait receivers from the fishing grounds to the rearing area, each of the eight corners of the octagonal bait receivers is provided with a 16 mm chain, weighing about 40 kg each, to keep the net taut. The size and weight of the chain are dependent on the size and dimensions of the bait receivers, and most importantly, on the mesh sizes.

The towing speed depends on current direction, current speed, wind speed, etc. but generally is between 0.5 and 0.8 knots. The towing speed is adjusted so as not to distort the shape of the bait receiver. Here also, the tugboat tows a series of receivers back from the fishing grounds.

g. Fishing period

Most of the fishing for live bait is conducted during winter. On my visit I saw an estimated 1,000 buckets of bait in a single bait receiver. It was 10-12 cm long and in excellent condition. These bait had been caught in December and had already been held for 2 months. This cooperative was expecting to sell this load in March, after 3 months of rearing.

Although anchovy are available throughout the year, most of these bait cooperatives discontinue catching them during the summer months because of the inescapably high mortality. During summer they changed over to rearing such fish as mackerel and bigeye scad.

3. Nagasaki Prefecture (Segawa Bay)

For sometime now I have read and heard about the excellent quality of bait at the Sasebo baiting ground in Kyushu. Some reports indicated that many fishermen considered bait from Sasebo to be of highest quality and that southern water fishing

vessels were partial to the Sasebo bait. In my visit to Nagasaki Prefecture, I learned that the so-called "Sasebo bait" is bait taken in Omura Bay, an enclosed bay located between Nagasaki City and Sasebo City.

In Nagasaki Prefecture the total annual catch of anchovy appears to be around 32,000 metric tons, of which 6%-8% is used as live bait. Most of the live bait is taken from within Omura Bay, while anchovy for processing is taken all along the western coast of Nagasaki Prefecture.

In 1973, about 2,113 metric tons of anchovy were taken in Omura Bay and sold as live bait. Vessels from various prefectures (Shizuoka, Mie, Kagoshima, Kumamoto, etc.) come here to purchase their bait. It was reported by this particular bait cooperative in Segawa that Kumamoto Prefecture regularly sends bait buyers here to purchase up to 60 cages (about 16 metric tons) of anchovy, and rear the bait themselves (in Omura Bay) especially for Kumamoto vessels.

a. Fishing method

In Omura Bay, as in other bait localities, fishing is largely by purse seining, but in addition, about a third of the bait catch is made by beach seining. Bait taken by beach seining is reportedly superior to that taken by purse seining. Beach seining includes a lightboat (with two 500-watt lamps powered from shore), which is anchored in the bay overnight to attract the fish. Early in the morning, at around 4 a.m., the school of fish is surrounded and the beach seine is hauled in by members of the bait cooperative.

Fishing for bait by purse seining is done in the same way as in the other bait localities visited. One big difference is in the use of bamboo cages rather than bait receivers to transport the bait back to the bay from the fishing grounds.

b. Bait receivers (ikesu) and cages (kago)

The bait receivers, which are located in calm waters of the bay, are generally octagonal in shape, 5.8-6.0 m (19-20 feet) to a side. The depth of the netting is about 8 m (25 feet). Many of the bait-receiver frames are constructed of 2-inch steel pipes and buoyed with eight floats. These receivers are set in water about 14-15 m (45 feet) deep. The netting is kept taut with a stone anchor at each corner, the anchor rope passing through loops of the netting

and attached to the bait-receiver frame. Furthermore, the top of the bait receiver is also anchored to shore on one end, and to the sea bottom on the other.

The bait-transport cages (kago) are constructed of woven bamboo strips, and measure approximately 2 x 3 x 3 m (6 x 10 x 10 feet). Each cage holds an estimated 400 kg (880 pounds) of baitfish.

According to an official of the cooperative in Segawa, there is great variability in the amount of baitfish loaded into a cage since this is done by "eyeball estimation." He estimated an average of about 30 buckets of bait per cage (roughly 13 kg per bucket). He added that even the unit of a bucket is extremely variable. For example, when the bait catchers sell their bait to dealers, they may sell about 15 kg of bait per bucket whereas when the bait dealers sell to fishing vessels the bucket may consist of 10 kg or less. One official remarked that the bait sellers purchase the bait from the bait fishermen for about 38,000 yen per cage (or 14 cents per pound).

c. Transfer of bait from purse seine to cages

In Segawa, the purse seining grounds are quite a distance from the bay. It may require up to 5 hours to tow the cages back to the bait receivers. One vessel in the baiting fleet handles the cages, carrying eight cages on its deck out to the fishing grounds, and towing the loaded cages back to the rearing area. When a school of bait is netted and concentrated in the bunt of the net, two men move a cage up to the net and submerge the cage below the surface to a position which will allow the bait to enter. The cages are sufficiently buoyant so that even when loaded with bait, they float to the surface. The loaded cages are towed back slowly and the baitfish are transferred to the bait receivers.

d. Fishing period

While bait-catching by purse seining is conducted only during the winter months (mainly October-December), when bait mortality is the lowest, beach seining is conducted throughout the year. The peak month for beach seining is in January, when as much as 80 cages of bait (about 32,000 kg) can be taken in a set.

e. Rearing of baitfish

About 200-250 buckets of bait are initially transferred to each bait receiver. After the initial mortality, the receivers are topped off with an additional 200-250 buckets of bait. Mortality is high during the first 3 days but levels out after that. The best temperature for rearing bait is about 20°C.

In February, when the temperature is around 7°-8°C, it takes at least 25-30 days of rearing before the bait are in condition to be sold to fishing vessels. At 14°-15°C, the required rearing period is about 13 days, and at 24°-25°C, it takes only about 7 days of rearing. In summer, when the temperature exceeds 30°C, it is not possible to rear baitfish in Omura Bay.

Feeding of baitfish need not begin for 20-25 days in winter, but when the temperature rises to around 20°C, feeding must begin after about a week. Food is generally commercial pellets, but some minced fish flesh is also utilized.

4. General Observations

a. Unit of measurement, the bucket, and selling price

It is obvious that in Japan, as in Hawaii, the unit of bait measurement, the bucket is quite variable. It not only varies from locality to locality, but even within the same locality. In some baiting areas, the bait seller measures the bucket (tends to contain fewer fish), whereas in some areas the buyer does the measuring (tends to be heavier). In general, it is reported that the bucket in the Kanto (central Japan between Chiba and Wakayama Prefectures) baiting areas averages around 3-4 kg of baitfish, whereas the bucket in the Sanriku (north of Ibaragi Prefecture, including the Tohoku area) and the Shikoku-Kyushu areas, is considerably heavier, averaging 6-7 kg or more of baitfish. The price per bucket of baitfish also varies greatly from locality to locality, but in general, it is around 2,900 yen (\$9.67) per bucket in the Kanto area and about 3,900 yen (\$13.00) in the Kyushu area.

b. Bait sizes

It is generally agreed that the ideal sizes of anchovy for skipjack tuna fishing are fish from 7-12 cm in length (average 10 cm). For albacore fishing, it may be slightly larger ranging up to around 14 cm. Fortunately, the 7-12 cm fish (2-year olds) appear to be quite strong.

c. Bait species

Anchovy makes up about 97% of the live-bait used in Japan. The remainder includes sardines (especially in the past 2 years when sardines began to increase), which in some localities, constitute up to 10% of the bait (mixed in with anchovy).

d. Bait fishing and rearing

It is obvious that successful capture and rearing of baitfish is highly dependent on the temperature of the water. Rearing is most successful during the winter when the temperature is low. Thus, there is very little fishing for bait during the summer months of July-September, when bait mortality is too high for an economical operation. Apparently, 28°C, is a very critical temperature, as above this, the mortality is very high regardless of how carefully the baitfish are handled.

e. Feeding of anchovy in bait receivers

There was some disagreement on just how long anchovy can be held in bait receivers before feeding is started. In Shizuoka and Oita Prefectures, it was reported that feeding should begin after about a week of rearing. On the other hand, in Nagasaki the bait people felt that in winter anchovy can be held for 20-25 days before any feeding is necessary. In any case, it is certain that no feeding is necessary for at least a week. Again, this is closely related to water temperature.

H. BAITFISH TRANSPORT

Because of the periodic bait shortages in Shizuoka Prefecture, a leading skipjack tuna fishing prefecture, three tuna boats have now been modified as bait transports. These vessels go to bait areas in Kyushu (Oita, Nagasaki, etc.) to purchase bait for transport back to Shizuoka to supply their own fishing vessels. The bait-carrying capacities reportedly range from 500 to 1,000 buckets per vessel.

It appears that the turn around time for these transports is about 10 days. Although no one I met was very well informed about this venture, they did indicate that the bait transport was quite successful in that they were experiencing 70%-80% bait survival. However, according to one bait cooperative official, who reportedly saw the condition of bait at the end of the transport, this bait

was arriving in Shizuoka Prefecture in relatively poor condition due to excessive handling. Nevertheless, it appears that bait will continue to be transported in order to supplement the supply in Shizuoka Prefecture. Most of the transport takes place between September and April.

I. ROBACK AUTOMATIC FISHING MACHINES

Although the ROBACK is but one of several models of automatic skipjack tuna and albacore fishing machines manufactured in Japan, this is probably the only model that has been exported. Presently about 14 units (hydraulic unit plus fishing poles) have been installed on Australian live-bait vessels. After the introduction of the first demonstration model on an Australian boat, orders for additional units have come in rapidly to the Iwatani Sangyo Company in Tokyo. Company officials said that the most recent order was to airfreight a unit so that the machines could be installed in time for the coming fishing season. The Australians have been enthusiastic about the performance of these machines, as attested to by the press releases. One report was of a 22-ton catch by an Australian vessel with a two-man crew, half of the catch having been made by two fishing machines.

In Japan, the company has installed about 400 units on Japanese skipjack tuna vessels. In the interest of making more sales in foreign countries, the company is anxious to let us have a demonstration unit for a greatly reduced price. It appears that we may be able to purchase a unit for under \$15,000 as compared to the company's listed price of about \$25,000 per unit.

J. USE OF LIVE MAAJI (TRACHURUS JAPONIGUS, BIGEYE SCAD) AS LONGLINE BAIT

The longline fishermen of Oita Prefecture in Kyushu began experimenting with live bigeye scad for longline bait beginning around 1966. The tuna longline fishery is based in Tsukumi City, Hoto Island. Presently there are 63 small longline vessels ranging from 19 to 39 gross tons operating out of this base. The fishing grounds extend from Japanese coastal waters to waters off Okinawa, Taiwan, and as far south as the Caroline Islands, as well as in the East China Sea. Fishing in coastal waters generally takes place between April and October.

These fishermen have generally relied on frozen squid, saury, and mackerel for longline bait. However, because of the high prices for squid, and the fact that mackerel tended to fall off the hooks much more readily than other bait, the fishermen have come to rely most heavily on saury.

The coastal fishing is principally aimed at taking bluefin tuna. Since the catch rates for bluefin tuna tended to be low, many of the Hoto Island fishermen were lured off the island vessels to join larger, distant-water longliners, and consequently the economy of the islands generally weakened.

Because of these circumstances, studies were begun in 1965 to strengthen the island's longline fishery, including the improvement of fishing gear and longline bait. Some modifications were soon introduced into the gear elements, but perhaps the most radical change came with the introduction of live fish as longline bait. Initially, live mackerel (Pneumatophorus japonicus) was tried and the catch rates for tuna improved by 1.7 times the catch rate obtained with frozen saury. However, the mackerel were relatively large, and only a small volume of fish could be held in the ship-board tank. Furthermore, they were relatively weak and about 60% of the mackerel died before the vessels even reached the fishing grounds. This prompted the trials with bigeye scad. These fish are smaller, and a greater volume could be carried in the tanks. Not only were they able to carry a supply of fish sufficient to last the entire fishing trip, but they found that the survival rate was at least 70%, a vast improvement over mackerel.

The catch rates of tuna using live bigeye scad were found to be 1.5 times better than with mackerel; or 2.6 times better than with frozen saury. The enthusiasm shown by the fishermen for this bait prompted the Oita Prefectural Fisheries Experimental Station to pursue intensive studies on the bigeye scad, particularly in regard to rearing small fish to bait size in fish-rearing enclosures. In 1966 about 40% of the total bait used by these longliners consisted of live bigeye scad, the percentage increased to 60% by 1967, and to 70% by 1970. Presently the use of live bigeye scad is on the order of 60%-70% of the total bait used.

The use of live bigeye scad for bait by the longliners was accompanied by other benefits...it became possible to also rear these fish to marketable size and thus to take advantage of the favorable market prices.

K. RESULTS OF REGULATION OF THE SOUTHERN BLUEFIN TUNA FISHERY

The Japanese, at the recommendation of the Japan Fisheries Agency, and through the cooperation of the Federation of Japan Tuna Fisheries Co-operative Associations, began voluntary regulation of the southern bluefin tuna fishery in 1971. The regulation involved the restriction of fishing in designated areas during specific periods of time. The primary objective was to protect the younger segment of the southern bluefin tuna population from fishing.

In 1972, it was reported that in spite of the regulation, the effective fishing effort for this species had actually increased rather than decreased, as it had been hoped. This was caused by more vessels joining the fleet to fish for the very highly priced sashimi fish. The average weight of the fish taken had decreased and the average age had decreased from 6.3 years in 1965-66 to 5.5 years in 1971-72.

In 1973, 2 years after the voluntary regulation went into effect, the resource level had continued to decline. The scientists at the Far Seas Fisheries Research Laboratory are of the considered opinion that the situation would have been far worse had this regulation not been in effect. However, it is now time to consider enforcing more stringent regulations in order to prevent further a decline in the southern bluefin tuna population. This may involve enlarging the areas of restricted fishing and/or lengthening the periods when no fishing would be allowed. If Korea and Taiwan enter the fishery for this species, it will present another problem. So far there is little indication that this will happen, except for one report of a Korean vessel recently entering Yaizu port to unload southern bluefin tuna.

L. ANTARCTIC KRILL

Last year, in my trip report I stated that the Japan Marine Fishery Resource Research Center had been conducting experiments in the Antarctic with a chartered vessel, the 2,000 ton Chiyoda Maru, and that they were still trying to develop an effective method of catching krill.

During the period October 1973-March 1974, the Center chartered the 1,500-ton No. 11 Daishin Maru, a stern trawler, to continue the survey. The vessel was equipped with a midwater trawl (total length 48.7 m, mouth opening 100 m²) as well as a "drag purse seine." The latter gear was hardly tested on this cruise. The midwater trawl results were generally excellent. The vessel found that the net can be towed in winds up to force 6-7. The trawl was towed at depths to 70 m but usually at the 15-30 m level. The trawling speed averaged 1.8 knots (1.6-2.0 knots). Most of the tows were for 30-60 minutes over patches of krill at least 150 m long.

The Center personnel feel that they have now perfected the harvesting method for krill. The chartered vessel caught an average of 10 tons per day for a total of 643 metric tons in 63 days of trawling. They reported that more could have been taken but the catch was limited by the processing capacity of the vessel. The maximum catch amounted to 30 tons per day.

Although the Center personnel regarded the No. 11 Daishin Maru (2,000 horsepower engine) too small for krill work, the consensus was that the trawl could still be increased by 50% in size for use by this vessel.

The krill taken were either boiled and frozen or frozen raw for return to Japan. Now that the capture method has been developed to a satisfactory degree, the Center officials believe that the next problem is to work on its utilization. At present, the krill can be boiled and dried for use as soup stock. However, the next move is to try to utilize the krill as a higher-priced ingredient for manufacture of such items as kamaboko and chikuwa (fish cakes). This will require the development of a technique to shell these little creatures. The Center plan is to supply krill samples to various food technology laboratories of commercial food firms to see if new products can be developed. In addition, the plan is to involve various university and government laboratories. For example, it was mentioned that Dr. Shigeno of the Utsunomiya University, who is a specialist on molds, is interested in working on the krill to see if he cannot modify the smell and taste of krill to make it more palatable and suitable for volume consumption. The claim is that krill is too strong in flavor for the Japanese people. Another consideration is to develop an FPC-like (fish protein concentrate) product using krill, but retaining its smell and flavor.

Center officials regard the development of a shelling method a most urgent problem. They proposed that it might be possible to shell krill by chemical means, just as the inner membrane of oranges is removed chemically in the canning process.

Krill fishing is apparently best during the summer months coinciding with their spawning season. January and February are regarded as the best months, but this may be due largely to the fact that weather conditions are best at this time of the year.

M. SARDINES

According to a Japanese press report, the sardines are definitely on a comeback trail in Japan. Catches began to increase in the spring of 1973 and the year's catch amounted to 200,000 metric tons. Good catches are continuing, and the expected 1974 catch is 500,000 metric tons. The increase in sardine landings was reportedly preceded by increases in landings of mackerel as well as saury.

N. LIST OF PERSONS CONTACTED DURING TRIP

Far Seas Fisheries Research Laboratory

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 Dr. Tadayoshi Ichihara, Chief, Fur Seal Research Section
 Dr. Akira Suda, Chief, Research Planning and Liaison Office
 Dr. Shoji Ueyanagi, Chief, Division of Pelagic Resources
 Dr. Ichiro Yamanaka, Chief, Division of Oceanography
 Dr. Sigeiti Hayasi, Division of Pelagic Resources
 Mr. Koichi Hisada, do.
 Mr. Misao Homma, do.
 Dr. Shoji Kikawa, do.
 Mr. Susumu Kume, do.
 Mr. Yasuo Morita, do.
 Mr. Yasuo Nishikawa, do.
 Mr. Chiomi Shingu, do.
 Mr. Toshio Shiohama, do.
 Mr. Jiro Suzuki, do.
 Mr. Jiro Morita, Division of Oceanography
 Dr. Keiji Nasu, do.
 Mr. Hajime Yamanaka, do.
 Mr. Mori Yukinawa, do.

Tokai University College of Marine Science and Technology

Dr. Motoo Inoue, Professor
 Dr. Mitsuo Iwashita, Professor
 Dr. Sigeru Motoda, do.
 Dr. Michitaka Uda, do.

Shizuoka Prefectural Fisheries Experimental Station, Yaizu

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Mr. Tsutomu Koto, scientist

April 10, 1974

Richard S. Shomura, Director, Honolulu Laboratory

Robert A. Skillman, Leader, Fishery Analysis Program

Trip report--Pago Pago, American Samoa to review sampling program for longline fishery (March 19-28, 1974)

The purpose of this trip was to 1) develop closer coordination between the canneries and other people directly associated with the fisheries operations, personnel of the Office of Marine Resources, and personnel from the Honolulu Laboratory in order to facilitate the collection of catch, effort, and size-sex data from the fishery; 2) discuss means of again collecting fork-length and sex data on albacore; 3) discuss the possibility of collecting data on yellowfin and bigeye tunas; 4) reach an agreement on the roles of Dr. Dick Wass, who is now in charge of the data collection program for the Office of Marine Resources, and personnel at our Laboratory, who process the data.

1. Coordination.

Dr. Stanley N. Swerdloff, Director of Marine Resources, setup meetings with the major participants in the longline fishery operations in American Samoa, which did not include the company representatives. In addition, I met several times with Dr. Swerdloff and every day with Dr. Wass to discuss various aspects of the fishery. I will briefly describe the meetings with the various people.

On Monday morning, 25 March, Dr. Wass and I met with Mr. Enti Liu, the Consul for the Republic of China, and Mr. Peter L. M. Kau, the Pacific Fisheries Attache. Mr. Liu participated in the preliminary discussions but deferred completely to Mr. Kau when we got down to fisheries problems. I could not get over the feeling that Mr. Kau acted like an old friend who was suffering from a psychological knife wound in the back. Aside from international politics, he mentioned that his country had been turned down in requests for data or information on the Samoan albacore fishery. I could not determine whether the request came from his office or from Taiwan. Mr. Kau did not feel that the reports that we are getting are necessarily accurate, since, and this is my personal opinion, he did not trust the accuracy of the daily catch and position data that the Taiwanese vessels must radio into him daily. In any case, I do not believe that Mr. Kau can be counted on for much support in getting the catch-effort log sheets from the Taiwanese longline vessels unless we can start providing him with some information on the fishery. Possibly the monthly summaries that Dr. Wass

and I discussed (to be described later) will be of some help. Mr. Kau indicated that the vessels have not been making good catches lately.

On Tuesday morning, 26 March, Drs. Swerdloff, Wass, and I met with Mr. Koh Dong Jae, the Fisheries Officer for the Republic of Korea. Mr. Koh was very interested in the report on the albacore fishery that I gave him and, in turn, gave Dr. Swerdloff a report by KMDC on their fishing operations in the Pacific. He has been very cooperative with Dr. Swerdloff, and this can be seen in the high percentage return of catch-effort log sheets from the Korean vessels. The Korean vessels fill in a log sheet that has been copied from ours, but I am not sure who receives these forms. I think we can look forward to the continued cooperation of Dr. Swerdloff's "golfing friend." Mr. Koh indicated that if the catches did not improve that some Korean vessels would probably leave the fleet.

On Wednesday morning, 27 March, Drs. Swerdloff, Wass, and I met with Mr. Ted Morgado, Fleet Manager for Star-Kist Foods, Inc. Mr. Morgado has carried over his scientific fisheries interest from his former job with us into his present position. He requires that the captains of the vessels contracted to Star-Kist turn in the catch-effort logs to him when they land fish. He studies these data logs and has a good understanding of catch trends by season and area. He is concerned about the vitality of the fishery. He was not only willing to help us get whatever data we needed but called for us to initiate more intensive studies on the biology and population dynamics of the fishery. Star-Kist receives shipments of skipjack tuna from various places in the western Pacific; it might be possible to get samples from these fish. Mr. Morgado remarked that the numbers of marlins and other miscellaneous fish coming onto the docks were exceeding the numbers indicated on the log sheets.

At Van Camp Sea Food Co., Dr. Wass and I talked to Mr. Vernon "Bud" Wright, Plant Manager, and Mr. Francis Yuhashi, Fleet Manager. Mr. Yuhashi seems interested only in managing the unloading and handling of fish and the provisioning of the vessels. Mr. Wright seemed very sincere in his interest for scientific research on the fishery. He was glad to receive the report on the assessment of the stock. He said he would help us in any way possible to obtain the catch-effort log book data as well as to collect information on length and sex of albacore. Mr. Wright has invited Drs. Stanley Swerdloff and Dick Wass to the monthly meetings in which various people associated with the fishery (both canneries, fishing company representatives, U.S. Coast Guard, dry dock facility (government operated) etc.) get together and discuss problems. He offered to call for the help of the fishing company representatives in getting the vessel captains to turn in the catch-effort data sheets.

2. Length-sex data for albacore.

Dr. Wass and I discussed with Mr. Wright the problems of obtaining a random sample of albacore when the fish are sorted into two or sometimes three sizes before being thawed and butchered. Stratified random sampling would be more difficult for the sampler to carry out and would be more difficult to design so that it did not interfere with cannery operations. We settled on a plan where 50 fish would be sampled at random from the fish as they were being unloaded. These fish would be placed into a bin that was marked as being sample fish. This bin would be handled the same as the other fish from the vessel, i.e., weighed, placed in freezer storage, and defrosted for processing according to the cannery's schedule. The sampler would have to determine or be notified when the sample bin was placed under the sprayers for defrozing so that he could schedule his time for sampling the fish. These kind of details would have to be worked out by Dr. Wass and Mr. Pulu Niuatoa of Marine Resources. I have, since returning to Honolulu, proposed this plan to Mr. Ted Morgado at Star-Kist.

3. Sampling of yellowfin and bigeye tunas.

As for obtaining samples of yellowfin and bigeye tunas, there seemed to be no great problem since they are unloaded along with the albacore. However, the fishermen seem to sort these species from the albacore until they have enough to make one load for the crane. They would have to be sampled before they are sorted into sizes in the storage bins.

4. Roles of Marine Resources and Honolulu Laboratory.

Basically, the role of the Office of Marine Resources will be to collect the catch-effort log book and length-sex data from the longline fishery, disperse summary reports to the major participants in the fishery, and maintain open communication with the major participants. The role of the Honolulu Laboratory will be to process the data both in terms of long-term assessments of the resource and also in supplying summaries of the state of the fishery on as timely a basis as possible.

It was apparent after talking with the cannery people as well as the fisheries officers for Korea and Taiwan that they need, or certainly want, summaries on the state of the fishery. Stated simply, they want something in return for their cooperation and help in obtaining data, and this something should be of use to them in maintaining an understanding of the trends in catch rates and distribution of the longline fleet.

After talking with Drs. Swerdloff and Wass, it became apparent that the computer summaries of catch and effort that we have been making are not and cannot be issued on a timely enough basis. These summaries are

important, useful, and Dr. Swerdloff wants them expanded to include all important species. However, because of the time delay in getting 100% of the log sheets before a report can be issued, they are not useful for any short-term studies. The last report that was issued covered data up through August 1972.

In order to provide more up to date information, we settled on two courses of action. First, Ray Sumida will be asked to provide a list of errors and omissions that are commonly made on the catch-effort log sheets. Dr. Wass will use this list to screen the log sheets as they are collected from the vessels. In this way, errors or omissions may be corrected before the vessel leaves on another trip, which is now averaging about 3 months, but can be as long as 6 months or more. Dr. Swerdloff reported that these log sheets are collected and sent to the Honolulu Laboratory about every 10 days. Second, after consulting with Dr. Wass, I proposed that we provide on a monthly basis a computer summary of catch per unit effort (hooks and days fished) by 5° rectangles for all the important species based on the data at hand. Though incomplete, these reports will give an indication of the state of the fishery. Also, they can easily be provided for each nationality in the fleet so that the country and company representatives may be appraised of the state of the fishery as viewed from their vessels. In order to provide these reports, the log sheets will have to be received and key punched on a regular basis.

In addition to the albacore subject, Dr. Swerdloff asked me to check into the uses that are being made of the temperature-salinity data that is being collected on a once a week basis. He also needs a computer update of this data, but after this updating he is not interested in receiving any more. He cannot see any seasonal trends in the data and wonders about the validity or usefulness of the data; there may be a serious freshwater contamination at the sample site during heavy rains. He plans on establishing a sampling station about 5 miles out from Pago Pago harbor at which the Alafaga will take an XBT sample (and salinity probably) whenever the vessel leaves port. I promised to check on the uses of this data and will be contacting Dr. Richard Barkley and Mr. Gunter Seckel. Also, Dr. Swerdloff asked me to help him in obtaining various oceanographic information on the area around American Samoa; I will be seeking Dr. Barkley's help on this subject.

Also, Dr. Swerdloff asked if we could provide him with computer summaries of catches of important species by month and 1° squares in about a 150-200 mile radius of American Samoa. Since this data need not be done on any tight time schedule, I indicated that we could probably provide it. Dr. Swerdloff wants these information to aid him in evaluating the potential for "local" longline and trolling fisheries.

RAS:ey
cc: Skillman
HL✓

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AQUACULTURE PROGRAMS IN HAWAII by Richard S. Shomura

and

AQUACULTURE OF BAITFISH by Walter M. Matsumoto

May 17, 1974

[Hawaii baitfish culture section input for the National Fisheries Plan.]

AQUACULTURE PROGRAMS IN HAWAII
(Prepared by Richard S. Shomura)

The following provides a brief summary of aquaculture activities in Hawaii. The list is far from complete; lack of time prevents an in-depth assessment:

Hawaii Institute of Marine Biology - University of Hawaii

The University of Hawaii through HIMB has a very active program in aquaculture; the program is principally funded by Sea Grant. HIMB has been working on aquaculture projects over the past several years, and various researchers have worked on various species and on a number of problem areas. Enclosed as appendix 1 is the material prepared by the program manager for 1974-75 Sea Grant support. In addition to these projects, HIMB also has a project to culture sharpnosed mollies as a possible baitfish species for skipjack fishing. Information on this project is detailed in the baitfish culture material submitted under separate cover.

State of Hawaii - Division of Fish and Game

The principal aquaculture project currently undertaken by the Division of Fish and Game involves the Malaysian prawn (Macrobrachium rosenbergii). State Fish and Game biologists have been successful in spawning this freshwater prawn and rearing the young through the larval stages with good survival rates. They have provided at least one commercial pond operator with a supply of young prawns. Data on yield and growth are currently being collected from this project.

The State has stopped work on the culture of (Crassostrea virginica). This species was introduced successfully in waters of Pearl Harbor decades ago; however, because of pollution problems the State has not been able to work out a means of successfully utilizing this resource. Attempts to establish or culture these oysters in several of the bays in Hawaii have not been successful.

The State has several other aquaculture projects dealing with freshwater species. One involves the hatching of 100,000 trout eggs received annually from the National Fish Hatcheries. The trout are reared through the larval and juvenile stages and released in streams on the island of Kauai. This program is directed to the use of recreational fishermen. A second freshwater culture project involves the channel catfish. Young channel catfish are hatched in experimental tanks and released in one of the reservoirs on Oahu as fingerlings. This program is also directed to the recreational fisherman.

Tap Pryor's Kohala operation

From newspaper accounts (copy enclosed as appendix 2) Tap Pryor is on the verge of a "systemculture" venture. Tap has been engaged in a number of culture projects in the past several years, e.g., culturing of spiny lobsters in French Polynesia. I hope this one doesn't turn out to be another "cat-rat on an island" scheme.

Oceanic Institute

The Oceanic Institute has recovered from the near-bankruptcy situation they faced last year. Currently their aquaculture program includes a project dealing with the reproduction and mass propagation of the grey mullet (Mugil cephalis). The Institute's biologists have been successful in inducing spawning of the mullet in tanks. Although they have tried for over a year, attempts at artificial spawning of the milkfish (Chanos chanos) have been unsuccessful. Another fish they are trying to culture is the mahimahi (Coryphaena hippurus). I believe the basis for work on all three species is the production of food fishes. I should point out that the young of mullet and milkfish have been used successfully as baitfish for tuna fishing. The problem is producing these fish to baitfish size economically enough for tuna operations. In addition to their biological projects, some of the staff members at Oceanic Institute are working on engineering and design studies to maximize the aquaculture operation, e.g., optimal pond configurations and rates of water flow.

AQUACULTURE OF BAITFISH
(Prepared by Walter Matsumoto)

I. The skipjack fishery

The pole-and-line fishery for skipjack tuna in Hawaii is the largest fishery both in catch and in value for the entire state. The fishery averages 4,450 metric tons per year with a range of 2,700 to 7,300 metric tons. In 1972 the total catch by this fishery was 4,950 metric tons, which had an ex-vessel value of nearly \$3,000,000. The pole-and-line fishery is primarily dependent upon the bait resource and problems encountered by the bait fishery ultimately affect the skipjack harvest.

The principal baitfish used by the Hawaiian skipjack fishery is the nehu (Stolephorus purpureus), a small delicate anchovy which possesses most of the qualities of a good baitfish. It occurs in bays and harbors in waters that are slightly brackish, but since these areas are relatively few and limited in size in the Hawaiian Islands and since each area is able to support only a small population of nehu, bait is frequently scarce, particularly during the summer months when the skipjack season reaches its peak. Additionally, the nehu is a weak bait and suffers substantial initial mortality (as much as 30 percent) despite careful handling. Nevertheless, the nehu accounts for about 92 percent of the baitfish caught in Hawaiian waters.

II. Problems faced by the fishery

1. Limited baitfish resource

Catch statistics of nehu provide a rough estimate of the size of the usable baitfish resource. In the 5-year period 1968-72, with 16 vessels operating full time, the annual catch of nehu averaged 36,000 buckets (1 bucket consisting of 7 pounds of baitfish), with a range of 30,000 to 42,000 buckets. In an earlier 5-year period, 1948-52, with the fishing fleet composed of 25-32 vessels, the annual catch of nehu averaged 38,000 buckets, with a range similar to that of the later period. During these periods also the average catches of skipjack were similar: 4,350 MT in 1948-52, and 4,250 MT in 1968-72.

The similarities in both the average catches of baitfish and skipjack between the two periods, despite the difference in fleet size, indicate that the catchable baitfish resource had approached its maximum level and that this baitfish resource was utilized as well with 16 as with 25-32 vessels. On the basis of these statistics it is evident that expansion of the fishery from its present level cannot come about simply by increasing the fleet size.

2. Loss of fishing time due to baiting operation

The nehu are taken both by day-baiting and by night-baiting. Because day-baiting consumes a full day (actual baiting time plus resting the bait overnight) the time used for day-baiting means a day lost for fishing.

In 1965 more time was spent in night-baiting, which provided 42 percent of the total bait catch. Since 1965, there has been a tendency towards more day-baiting. The time spent in day-baiting accounted for about 40 percent of the total activity of the fleet in 1971. For some vessels, however, the time spent baiting was as much as 50 percent.

3. Threat to baitfish resource

Within the Hawaiian Islands there are several baiting grounds, the most important being situated in Kaneohe Bay. During a peak year as many as 20,000 buckets of bait have been seined from this bay (Baldwin, 1974). But Kaneohe Bay is in an area of rapid urbanization and is subject to increasing amounts of sewage and siltation. This continual environmental degradation may have a direct effect on the stocks of nehu there and eventually could result in the loss of Hawaii's most productive baiting area.

III. Consequences of the bait problem

The effects of the baitfish problems on the fishery are quite evident. First, the scarcity of bait probably has contributed to the decline in the number of vessels from a high of 32 in 1948 to the 16 presently in the fleet. Poor economics of the fishery which includes a disproportionate loss of time due to baiting operations has deterred owners from replacing lost vessels. Second, the lack of a bait strong enough to withstand the rigors of handling and capable of prolonged survival in the baitwells has prevented the development of a fleet of long-ranged vessels equipped with refrigeration capability. Only one such vessel, the Anela (136 gross tons), was added to the fleet in 1971. It was the only addition since 1955 and only the third fishing vessel built since 1948.

Consequently, the fleet is comprised almost entirely of outdated vessels with limited range and without refrigeration, and the fishery is thus restricted to coastal waters well within 90 miles of shore. The dwindling fleet and the present reluctance of the boat owners to replace lost or retired vessels should be cause for alarm, but this situation could be changed with an improvement in the bait supply.

IV. Alternate methods for increasing catches

The Hawaiian skipjack fishery is subject to large fluctuations in catch. There is some basis to believe that these fluctuations are related to the northward movement in the spring and summer of low salinity California Current Extension (CCE) water that replaces the high salinity North Pacific Central water in the Hawaiian region. Intrusion of the CCE water coincides with the seasonal increase of skipjack landings. Failure of this water to move into the fishing area results in low catches (Seckel, 1972). The present fleet of small, short-range vessels is particularly susceptible to yearly deviations in the northward movement of the CCE water. Long-range vessels could overcome this problem by seeking favorable waters and possibly areas of better fishing further offshore. The development of such a fleet, however, depends entirely upon the development of the bait resource.

Increases in the catches are also likely within the present fishery. One approach to increasing the present catch is to separate the bait fishery from the skipjack fishery, thus permitting the fleet to spend more time fishing for skipjack. Obviously a reduction in the time spent in day-baiting operations would provide more time for fishing. If all time lost in day-baiting were eliminated and the savings in time were channeled into skipjack fishing and if this situation were coupled with an adequate bait supply, the annual catches could be increased by about 60 percent. In 1972, for example, the catch could have been increased from 4,950 metric tons to 8,100 metric tons and the ex-vessel value from \$3,000,000 to \$4,800,000.

The development and maintenance of a separate bait fishery can be successful only if the net value of the increased catch substantially exceeds the cost of producing the bait. Three avenues are open to develop a separate bait fishery; (a) culture baitfish species found locally, (b) culture introduced species, and (c) transport baitfish in large quantities from areas presently endowed with a large resource, i.e., from California, on a regular basis. While transporting of baitfish from California is a more direct approach to the problem, and such a project already has been initiated by the Service, the alternatives involving aquaculture also should be pursued.

V. Aquaculture of baitfish

1. Tilapia

Attempts at aquaculture of introduced baitfish species have been made by the Service and by the Hawaii Division of Fish and Game, the most successful being with the tilapia (Tilapia mossambica). Following its initial successful introduction in ponds and reservoirs by the Hawaii Division of Fish and Game and successful tests as a baitfish (King and Wilson, 1957), a pilot study was made for tank culturing in 1958-59 (Hida, Harada and King, 1962). The pilot study was made because bait-sized young could not be produced in the wild in sufficient quantities owing to cannibalism and predation and to difficulties in harvesting. The 9,300 square feet (surface area of all tanks) pilot study plant located on the island of Maui produced about 470 buckets of bait in each of the two years. On the basis of this study it was estimated that tilapia could be cultured for \$1.00 per pound in a plant having 16,000 sq. ft. of brood-tank space and 40,000 sq. ft. of fry-tank space, and that such a plant could produce up to 6,000 buckets of bait annually.

Following this study, the Hawaii Division of Fish and Game experimented with culturing tilapia in 1961 on the island of Oahu, where most of the fishing fleet is based. Although the production of bait-sized tilapia was good, the lack of interest by the fishermen in use of the bait compelled the State to abandon the operations (Hawaii Dept. Land and Nat. Res. Ann. Rep. 1964-66).

2. Threadfin shad

Another attempt at aquaculture of baitfish was made with the threadfin shad, Dorosoma petenense. This species, introduced in 1959, became established in three reservoirs within a year. Shad held in tanks failed to spawn but those released in reservoirs spawned successfully. An estimate made of the bait-sized shad in one 302-acre reservoir in the summer of 1970 amounted to a minimum 5,000 buckets. Tests of this species as skipjack bait showed it compared favorably with nehu in its behavior and was hardier and easier to handle (Iversen, 1971).

An economic feasibility study producing shad as live bait was made under the joint sponsorship of the Economic Research Center, University of Hawaii and the Service's Honolulu Laboratory (Shang and Iversen, 1972) following the successful sea trials. Results of the study indicated (a) that shad culture is feasible with an annual production of 3,600 buckets per ten-acre pond unit, (b) that the breakeven price would range from \$11 to \$15 per bucket, a price that the fishermen are willing to pay, and (c) that 9 to 13 ten-acre ponds would be required to produce shad equal to the amount presently used by the skipjack fishery. The study also provided a cost estimate of \$63,500 for the construction of a ten-acre pond and \$19,300 to operate the facility annually.

3. Mollies

The feasibility of raising large quantities of the sharpnose molly (Poecilia sphenops) under intensive aquaculture is under study at the Hawaii Institute of Marine Biology, University of Hawaii (Baldwin, 1974). Preliminary work with this species indicates that it has potential as a baitfish and can probably be supplied to the fishery in large quantities on an extended basis. Tests are sea are currently being planned to determine how effective mollies are as tuna baitfish. Since natural supplies are insufficient for these tests, it will be necessary to raise them in captivity. A program has been initiated with the cooperation of the Hawaii Division of Fish and Game to raise mollies at the State's aquaculture plant at Sand Island. This phase of the project will require at least two years to complete and could provide information necessary to determine whether or not intensive culture is warranted.

The experience with the tilapia and shad culture and the present work on the mollies point to the possibility of aquaculture as a means of increasing the baitfish supply, not only to meet current demands but also to permit an increase in the number of vessels in the fleet. Additionally, these studies have shown that the technological skills exist and that there is a willingness of the State, University and industry to cooperate in such ventures.

4. Other species

The Pacific Island Mariculture Conference held in Hawaii in 1973 suggested other likely candidates for baitfish species. These include the mullets (Mugilidae), the goatfishes (Mullidae) and the cardinalfishes

(Apogonidae). All of these have been used as baitfishes on occasions and have proven to be excellent. With the exception of the mullets, there is a lack of knowledge concerning the culturability of these fishes. Studies to determine their biology may well be worth the effort. The biology of the mullets is reasonably known and although these fish have been cultured from beyond the juvenile stages, recent advances in techniques to induce spawning in tanks of at least one species, Mugil cephalus, make this a prime candidate for further study.

VI. Answers to questionnaire relative to baitfish culture

Public aquaculture

At the present time there is no public aquaculture of skipjack baitfish in Hawaii, the only area in the Southwest Region with such a need. While the technological base is adequate to permit development of public aquaculture, other problems such as the scarcity of suitable lands for aquacultural plants could seriously limit such developments. Nevertheless, some aquaculture has been done before and is needed to develop a better bait resource.

The successful culture of tilapia has been proven; however, the lack of interest in its use makes this a questionable species. In defense of tilapia as a baitfish, it should be pointed out that the rearing program was carried out in two consecutive below-average fishing years, when the demand for bait was not great. Successful use of this species requires breaking down of the fishermen's ingrained distrust of tilapia. Barring this, further studies are needed on the shad, a baitfish that has proven to be as effective as the nehu and more readily acceptable to the fishermen than tilapia.

Past work with shad has involved only pond culture and, as in the case with tilapia, harvesting the fry could be a problem. Trials involving tank culture are in order, now that some knowledge has been gained about its spawning habits. Tank culture would insure that all of the fry produced would be utilized.

Private aquaculture

At the present time there is no private aquaculture of baitfish in Hawaii. While there is a potential for private aquaculture, the possible development of other means of fishing not requiring the use of baitfish, such as an improved purse seine or seining technique suitable for local waters, could affect it adversely. The development of a purse seine fishery, however, would not eliminate all pole-and-line fishing, as witnessed in the eastern Pacific fishery. The need for baitfish would still exist, at least for the present fleet. If private aquaculture at this level is contemplated, there would be a need perhaps for a pilot study plant and certainly for commercial scale production tests to provide likely entrepreneurs with sufficient data to allow a determination of profitability. The baitfish species, initially, would have to be the shad, which is acceptable to the fishermen.

The culture tanks on Sand Island could serve as a pilot plant and eventually as a bait-holding facility. Since the tanks are operated by the State, these studies could be made in cooperation between the State and Federal governments.

References

Baldwin, W. J.

1974. Raising mollies for skipjack bait may eliminate use of frail nehu. Nat. Fisherman, Jan. 1974, 54(9):7.

Hida, T. S., J. R. Harada, and J. E. King

1962. Rearing tilapia for tuna bait. Fish Bull, U.S. 62(198):20 p.

Iversen, R. T. B.

- 1971 Use of threadfin shad, Dorosoma petenense, as live bait during experimental pole-and-line fishing for skipjack tuna, Katsuwonus pelamis, in Hawaii. NOAA Tech Rep. NMFS SSRF-641:10 p.

King, J. E., and P. T. Wilson

1957. Studies on tilapia as skipjac bait. U.S. FWS, SSR-F. No. 225: 8 p.

Seckel, G. R.

1972. Hawaiian-caught skipjack tuna and their physical environment. Fish Bull, U.S. 70(3):763-787.

Shang, Y. C. and R. T. B. Iversen

1972. The production of threadfin shad as live bait for Hawaii's skipjack tuna fishery: an economic feasibility study. Univ. Hawaii, Econ. Res. Center (ERC):42 p.

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SEA FARMER—Taylor A. (Tap) Pryor has had "picturebook results" with his clam and oyster operation at Makapuu.—Photo by Warren R. Roli.

Pryor Has Hopes for Sea Farm

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A few years ago Taylor L. "Tap" Pryor was dashing around the country looking for money to keep the Oceanic Foundation at Makapuu alive.

Now he can be found most days tending seafood crops at the old Makai Range pier, and he's as happy as one of his succulent clams.

He says he has developed a system of marine farming which can turn out cocktail-size oysters in months, instead of years.

He hopes to go into full-scale seafood production — starting with oysters and clams — in the Big Island's Kohala sugar area.

He is negotiating with Castle & Cooke for 75 acres of cane land at North Kohala for a "marine plantation."

A FLAMEBOYANT innovator, Pryor founded the

Star-Bulletin



Wednesday, April 10, 1974

complex of oceanic facilities at Makapuu — Sea Life Park, Oceanic Institute and the Makai Range.

The range closed two years ago with heavy money losses. The Oceanic Foundation crumbled financially but was restored under federal bankruptcy proceedings and reportedly is doing well now.

Pryor, 42, is a trustee but no longer president of the foundation.

Little has been heard of him during the foundation's reorganization — a contrast to previous years when he was constantly in the news with his bold ideas and marine activities.

But he has been busy and he is still brimming with ideas, now in aquaculture.

"I KNEW something

year-old oysters raised in Seattle, and can even control the taste and color by raising them in seawater, brackish water or a fishpond environment.

Market studies conducted for Pryor's Kohala venture show an excellent market for fresh oysters and clams with an estimated sales income of up to \$2 million in the first full year of production.

He plans to operate 15-acre farm units. He said these will cost about \$500,000 each to install. He will train Kohala residents for the operation and said he will have a residence there.

State Agriculture Chairman Frederick Erskine, vice-chairman of the Kohala Task Force, said the task force has approved the oyster and clam farm in concept and turned it over to its executive committee to arrange financing.

He said the task force has emphasized that it wants "concentrated effort without dilution."

PRYOR ALSO must provide a lien-free equity contribution. The leases to the fish farm site, makai of the Hawaii Biogenics Inc., operation, must be completed before the task force can finance the project, Erskine said.

Pryor coined the word "systemculture" for his project.

He said it means the use of facilities with a single, or uniform, design to rear many species of marine organisms. The system is unique and economical because it doesn't have to be changed with the addition of a new fish crop, he said.

He said, "I should have understood it when I finished Sea Life Park because basically all it is is an oceanarium."

It involves pumping large volumes of seawater to masses of marine animals, as exhibit oceanariums do, with food distributed on a mass scale in the water.

Pryor said the idea to put two or more aquatic animals into the system so waste from one will benefit the other.

HE USES turtles for effluent to enrich the phytoplankton for his clam and oyster crops at

"I KNEW something about aquaculture from 10 years of involvement and a great many speeches," he said in an interview at his Makapuu office.

"But two years ago I began studying all the aquaculture I could ... and some of the big blunders in the United States."

Drawing on his experience and the results of several fish-rearing projects on the Mainland, Pryor put together a prototype production facility with a \$50,000 grant from the State — financed Kohala Task Force. He also conducted trials in a flume in a Kaneohe Bay fishpond.

The 90-day study began Jan. 1. Pryor said he has had "picturebook results ... terrific production, exactly as we hoped."

phytoplankton for his clam and oyster crops at the Makapuu production facility. He also uses some commercial fertilizer and has tried an assortment of diets and nutrients, seeking the best combination for maximum fish growth.

Hawaii's tropical conditions — warm, clean seawater, year-round sunshine and tradewinds — are ideal for the system, he said.

He started with oyster and clam seeds from hatchery sources. "They send them in about the size of small tomato seeds. Six months later, they're about three inches," he said.

He said he's tasted them and they're delicious. "Buyers here like them because freshness is an important part of oyster quality," he noted.

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NATIONAL MARINE FISHERIES SERVICE
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NATIONAL FISHERIES PLAN: FISHERIES DEVELOPMENT TASK FOR THE CENTRAL
AND WESTERN PACIFIC REGION. Paul J. Struhsaker (Compiler)

May 22, 1974

BOTTOMFISHES

Introduction

The bottomfish resources of the central and western Pacific are represented by many families of tropical fishes. Two general categories are considered for the following Task Questionnaire. The reeffish resources (those species occurring in the nearshore and reef environments and usually within diving depths) are dominated by the following families: Holocentridae (squirrelfishes), Serranidae (sea basses), Priacanthidae (bigeyes), Carangidae (jacks), Lutjanidae (snappers), Mullidae (goatfishes), Labridae (wrasses), Scaridae (parrotfishes), Acanthuridae (surgeonfishes), and Scorpaenidae (scorpionfishes). These species are harvested by handlines, traps, spearing, gill-netting, and other methods. The outer-shelf and upper-slope resources are dominated by the Lutjanidae, Serranidae and Carangidae. These species are taken by handlines and, occasionally, traps.

These fishes are taken almost exclusively for local consumption, although some transshipment of catches occurs within regions. These resources are heavily fished in some areas. For example, we have estimated that the near-shore production of these groups may be as much as 400-500 kg/km² for the island of Oahu in Hawaii. Further development of these resources in all areas will depend largely upon increased local demand.

I. Resource

- A. Except for the Hawaiian Islands, no reliable catch statistics for bottomfishes exist for the central and western Pacific island areas. Presently, about 800 MT of these species are produced in Hawaii. The current product trends are generally steady, with modest increases from year to year for certain species. Estimation of time tables for the full commercialization for most forms is not presently feasible.
- B. Further development of these resources would not reduce pressure on other fisheries.
- C. Generally quite stable.
- D. No foreign competition.
- E. Very little is known of the extent of these resources, as is also the case of biological information for their management. Much additional information for all the Pacific areas is desirable.

II. The Technology

- A. There are no major obstacles for further development of these resources.
- B. Further development would depend on implementation of existing technological methods in the fields of harvesting, catch preservation methods and facilities, and transshipment.

III. Industry Capacity

A. Harvesting capacity.

1. Present harvesting methods and vessels are generally suitable.
2. Established fisheries are suitable.
3. Efficiency is moderate.
4. Little difficulty. This would be an expansion of existing fisheries.
5. Highly variable. Even moderate production increases would attract additional harvesting capability.
6. and 7. Not applicable.

B. Processing Capacity.

1. Most products are sold to the fresh or frozen markets, and further expansion of existing capabilities is all that is required.
2. Adaptation of existing technology would be necessary in the case of developed export market.

IV. Employment

- A. Harvesting and processing labor would not be difficult to attract.
- B. The usual shore-based employment opportunities compete for harvesting labor.

V. Market Factors

1. Imported frozen fishery products currently compete with local fisheries in Hawaii, American Samoa and Guam.
2. Fresh and frozen whole fish.
3. Market trends for competing items probably will not change dramatically.
4. No major changes anticipated.

VI. Consumer

- A. There are long-run potentials for bottomfishes in the following categories:

3 (Bottomfishes)

1. Domestic. Perhaps international in some cases.
2. Retail food chain and white-tablecloth restaurants.
3. Local (each island area) and regional (West Coast).
4. Fresh and frozen.

- B. 1. Favorable.
2. No effect.
 3. Unfavorable.
 4. Favorable.
 5. Unfavorable.
 6. Unfavorable.
 7. Little effect.
 8. No effect.

VII. Economic Feasibility

- A. Further commercialization of these species would be an expansion of existing fisheries.
- B. Further information on the extent of resources in more distant areas is required.

VIII. General

- A. Industry level of involvement is high. State involvement consists of modest participation through maintenance of catch statistics and some management regulation enforcement.
- B. Increased NMFS activity through a harvesting and infrastructure development plan would be followed almost immediately by increased production.
- C. The institutional barrier of the general public's lack of familiarity with most tropical bottomfishes is a deterrent to rapid expansion of these resources. No legal barriers are foreseen.
- D. No major environmental constraints. The presence of ciguatera in certain island areas prohibits the utilization of many species there.

E. Conflicts between commercial and sports groups may develop in the long run, but no difficulties are foreseen at present.

F. Substantial commercialization of underutilized species should be underway by 1985.

NERITIC SPECIES

Introduction

There are indications that the "mackerel scad" resources of the Pacific are considerable. These carangid fishes of the genera Selar (= Trachurops) and Decapterus are usually taken by handlines at night or with surround nets when they aggregate inshore during daylight hours. The Hawaiian harvest of this species group during 1973 was about 400 MT, second only to skipjack tuna. Most of this catch comes from the island of Oahu, with lesser amounts from the "outer islands." Production is more or less limited by local demand, and the akule, Selar crumenophthalmus, is now the most important "table fish" in the Hawaiian diet.

Surveys and local knowledge indicate that species of these genera are abundant in other Pacific areas of interest to the United States. Further production would depend upon increased harvesting capacity for local consumption, and product and market development for exportation. An example of what a concerted development program can accomplish is illustrated by the Philippine Islands: a U.N.-sponsored project on improvement of harvesting and catch preservation methods has resulted in an annual production exceeding 350,000 MT there.

I. Resource

- A. The present yield is known only for the Hawaiian Islands where the trend is generally upward. Maximum production will probably be obtained sometime in the 1980's. It is difficult to estimate the impact of a development program, but the development of an export market would considerably increase the rate of harvest.
- B. Further development of this fishery would not relieve much pressure on existing fisheries.
- C. Marked fluctuations in stock sizes have not been noticed.
- D. No foreign competition is expected.
- E. Virtually no knowledge exists on the status of these stocks in the Pacific area other than for Hawaii.

II. Technology

- A. Further development of these resources would depend upon demand for these products in other than the areas of harvest. A two-three year program of market promotion for the frozen product would determine the feasibility of exporting these species.
- B. Marketing of these species as kippered or smoked products might increase the demand, both locally and regionally.

III. Industry Capacity

A. Harvesting capacity

1. Small and medium-sized vessels take these species by handlining and surround net.
2. Harvesting capacity currently exists. Not much modification required.
3. Methods are fairly efficient.
4. Only moderate difficulty to increase production.
5. A continuation of the present price structure for effort-return would be necessary.
6. and 7. Not applicable.

B. Processing capacity

1. The present processing and handling facilities in the Hawaiian Islands could handle a general increase in production.
2. New handling and processing facilities would need to be developed for an export market.

IV. Employment

- A. No problem to attract more harvesting and processing labor.
- B. Shore-based employment competes for harvesting labor.

V. Market Factors

1. Imported fishery products currently compete with products of these fisheries.
2. Fresh and frozen. Perhaps dried, smoked or kippered products in the future.
3. Increased product from other fisheries would not have a large effect on the scad fisheries.
4. No major changes expected.

VI. Consumer

- A. Long-run potential for:

3 (Neritic Species)

1. Domestic. Perhaps international in the future.
2. Retail food chain, white-tablecloth restaurants.
3. Local (Pacific Islands); perhaps regional (West Coast) and national.
4. Fresh, frozen, smoked.

- B.
1. Favorable.
 2. No effect.
 3. Unfavorable.
 4. No effect.
 5. Unfavorable.
 6. Favorable.
 7. No effect.
 8. No effect.

VII. Economic Feasibility

- A. No, for further expansion of the fishery.
- B. Extent of the resource in areas other than the Hawaiian Islands must be determined. Market acceptance in areas other than Oceania must be determined. The NMFS could undertake this program.

VIII. General

- A. High industry involvement in the Hawaiian Islands.
- B. One-three years after an NMFS development plan.
- C. None for local consumption. Market acceptability for exportation to mainland U.S.
- D. No environmental constraints foreseen, except for gross degradation of inshore habitats.
- E. None.
- F. Very good.

Introduction

DEEPWATER SHRIMP RESOURCES

Recent investigations by the NMFS and the Hawaii Institute of Marine Biology have demonstrated that three deepwater species of shrimp occur in the Hawaiian Islands in quantities sufficient to support commercial fisheries. The one penaeid and two caridean shrimps and their approximate depth ranges are:

Penaeidae

Penaeus marginatus Randall 60-120 fathoms

Pandalidae

Heterocarpus ensifer Milne-Edwards 100-350 fathoms

H. laevigatus Bate 250-400 fathoms

Only data from exploratory fishing data and some informal results of test fishing by commercial fishermen in the Hawaiian area are available for the following account. There is some potential for the Guam area where the Guam Marine Laboratory has undertaken some initial surveys based on the results obtained in the Hawaiian Islands. Perhaps some limited grounds exist in the northern Marianas near Saipan, as indicated by C. & G. S. charts. Otherwise, most of the Trust Territory island areas and American Samoa offer very little area in the depth ranges in which these species occur.

REFERENCES:

Struhsaker, P. and D. C. Aasted.

MS. Deepwater shrimp trapping in the Hawaiian Islands. Mar. Fish. Rev.

Struhsaker, P., H. O. Yoshida, and R. S. Shomura.

MS. Exploratory shrimp trawling in the Hawaiian Islands. Mar. Fish. Rev.

I. RESOURCE

A.

1. Present production is less than 5 metric tons per year of Heterocarpus spp. Estimated MSYs per annum (based on catch rates and estimated amounts of fishable grounds) are as follows.

P. marginatus 50 metric tons

H. ensifer 1,000-5,000 metric tons

H. laevigatus 500-1,000 metric tons

2. The production trend at present consists of a few, small sporadic landings of Heterocarpus.
3. Although there are no current production trends of these species, once exploitation begins production should rise rapidly.

P. marginatus: 2 years after full-time production.

Heterocarpus spp. 1980-1985.

4. P. marginatus

One year after a subsidized commercial production attempt.

Heterocarpus spp.

One-two years after a development program. There are indications that a NMFS sponsored development program may not be necessary.

5. These potential fisheries should be commercialized to a considerable extent by 1980.

- B. A trap fishery for Heterocarpus would probably attract a few vessels from the small Hawaiian tuna longline fleet.
- C. Stability of shrimp stocks unknown, although limited exploratory fishing surveys demonstrate that they are not prone to great fluctuations in abundance.
- D. No foreign competition ^{seen}forseen. Most potential grounds within the 12-mile contiguous fishery zone.
- E. For all three shrimp species the sustainable production levels are unknown. These should be determined for selected areas as well as basic life-history parameters for management purposes.

II. THE TECHNOLOGY

- A. P. marginatus. The only major obstacle to the development of this resource is the lack of a suitable trawler-rigged vessel in the Hawaiian Islands.
Heterocarpus spp. Major problems in the development of these resources are: catch handling and preservation; processing for peeled, deveined, and frozen product; and product marketing.
- B. The technology exists to resolve all of the above problems.

III. INDUSTRY CAPACITY

A. Harvest capacity

1. Vessels 35-75 feet in length with deep-water trapping and trawling capabilities are required.
2. Harvesting capabilities are available. However, no suitable trawler presently exists in the Hawaiian area. Some local vessels could be modified for shrimp trapping.
3. These vessels have exhibited their efficiency in other trawl and trap fisheries.
4. Moderate difficulty for small trap vessels: the new fishery must show evidence of higher than average return on the investment.

Difficult for larger trawlers. Most vessels of this type are presently engaged in an attractive return fishery.

5. Small trapping vessels: \$50K per annum

Larger trawling vessels: \$125-150K per annum

6. Not applicable.

7. Not applicable.

B. Processing Capacity.

1. For products directly sold to the local markets, handling and processing capabilities currently exist.
2. Processing of H. ensifer for a peeled, deveined, frozen, and export market (to U.S. mainland) would require modification and testing of available processing machinery. A pilot plant would also be desirable to develop optimum handling techniques. Depending upon the extent of the development program, this phase could be completed in 6-24 months at a cost of (shooting from the hip) \$50-500K. A portion of this phase should quite probably be conducted by private enterprise.

IV. EMPLOYMENT

- A. Harvesting and processing labor forces are available.
- B. Most shore-side jobs now strongly compete for harvesting labor. However, sufficient personnel probably could be recruited to a relatively small shrimp fishery. There should be no strong competition for semi-skilled processing labor.

V. MARKET FACTORS

A. Local Market. There should be no problem in supplying the local fresh and fresh-frozen whole shrimp market.

Demand for such products is unknown and can only be determined with development of the fisheries.

Processed Shrimp Tails. A quality processed shrimp product should find a ready outlet both locally and on the mainland U.S.

Exportation. Whole frozen and processed tails could possibly compete in the foreign export markets.

The products would probably have a long-run potential in the following markets.

1. Domestic and international.
2. Retail food chain, white-table restaurants (who came up with that one?), and institutional markets.
3. Local (Oahu and outer islands) and Regional (U.S. West Coast).
4. Fresh and frozen.

B.

1. Favorable.
2. No effect.
3. Some adverse effect.
4. Favorable
5. Unfavorable.
6. Unfavorable.
7. Little effect
8. No effect.

VI. ECONOMIC FEASIBILITY

- A. Considering the present world-wide demand for shrimp products, it would seem that eventual development of these resources is inevitable.
- B. Determination of resource bases, approximate production figures, quality of processed products, and market acceptability. These projects should be undertaken by both Industry and the NMFS^F.

VII. GENERAL

- A. Moderate interest on the part of the local fishing industry.
- B. Within 1-2 years of intensive NMFS testing and development program.
- C. None
- D. Serious degradation of the inshore environment would probably adversely affect the survival of young P. Marginatus.
- E. None.
- F. I figure that by 1985 we could just about have the deepwater shrimp resources of the Hawaiian Islands wiped out!

OCEANIC SPECIES

The development plan for the skipjack tuna resource of the central and western Pacific is covered by the PIDC document. Further production of oceanic species of fishes in this region could be effected by small- and medium-sized vessels working out of insular areas and utilizing improved means of harvest. The NMFS may wish to consider modest developmental programs for the following species. Experience gained from these programs in the Hawaiian Islands could be applied throughout the central and western Pacific.

Yellowfin (and bigeye ?) tuna: There are indications that medium to large yellowfin, and perhaps bigeye, tuna are associated with the outer shelf areas of the Hawaiian Islands in depths of 100-200 m. These are taken occasionally by live-bait boats when they have an adequate supply of bait and skipjack tuna fishing is slow. An experimental program during one summer season consisting of deep-trolling and drift fishing should provide a preliminary assessment of the efficacy of these fishing methods. An increased supply of large tunas would contribute to the local and Hawaiian export market to the U.S. mainland.

The current production of these two species from Hawaiian waters is about 550 metric tons. These methods could possibly result in an increase of 50-100 metric tons.

Albacore: Recent longline experiments near Fiji have demonstrated that large albacore occur at considerable depths in the tropical central Pacific. Catch rates there have ranged up to 3%-5% at depths of 200-400 m. The experimental gear is not considered practical for commercial use at present, however, and new techniques would have to be developed to fish these depths. Personnel at the Honolulu Laboratory have conducted a preliminary design study of deepwater commercial longlining system and feel that it is practical.

The primary constraint on increased albacore production in the Hawaiian Islands is that this species is not desirable for use as sashimi. However, this species commands the highest price of all tunas for canning purposes. With a marked production increase in the central Pacific, canning could be carried out in Hawaii, or the raw material transshipped to the west coast.

Current Hawaiian landings of albacore are only about 15 metric tons. Annual landings of at least 500 metric tons would be desirable for the development of a fishery directed to the canning industry.

Skipjack tuna: Under the current PIDC tuna development plan, the Government of American Samoa will undertake surveys to determine the feasibility of small-craft trolling as an alternate harvesting technique for skipjack tuna. This has already been proven feasible in the Ponape District of the Trust Territory (for local markets), but it is desirable to learn if this fishing method can produce substantial catches that could provide increased production for local markets, transshipment and the Honolulu cannery. Possibly, the Honolulu Laboratory could undertake Hawaiian trolling experiments in conjunction with those being conducted in American Samoa. The advantages would be the presence of a commercial fleet against which the trial landings could be compared and the close proximity of fishing supplies and support facilities.

A small vessel would have to produce about 40 metric tons during the 3-4 month fishing season to be economically feasible.

Mahimahi (dolphinfish; *Coryphaena*): The bulk of mahimahi landed in the Hawaiian Islands is taken incidentally by commercial and sport fishermen and goes directly to the fresh fish market. Most of the mahimahi utilized in the restaurant trade, however, consists of foreign-caught imports. Quite probably some of the chance could be removed from the incidental catches by the placement of floating objects that would attract mahimahi such as is the practice in the Sea of Japan.

The Honolulu Laboratory plans to undertake an experiment in the aggregation of skipjack tuna schools. The experiment is designed to simultaneously determine the effect on mahimahi schools. A concerted effort in the placement of floating objects by the NMFS and perhaps private individuals could conceivably result in a greatly increased production of mahimahi (and tunas).

OTHER SPECIES GROUPS---TRUST TERRITORY, AMERICAN SAMOA, AND GUAM

The following species groups in the Hawaiian Islands are currently being exploited at nearly maximum levels. The following comments apply to other Pacific areas, particularly the Trust Territory. It is not clear what, if any, roles the NMFS should play in the development of these resources.

Tuna baitfishes: Recent work by several agencies has provided us with a fairly good assessment of the baitfish resource in the Trust Territory. Utilization of these live-bait resources for skipjack tuna fishing is discussed in the PIDC document. Surveys by the Honolulu Laboratory have shown that the sardine Herklotsichthys punctatus occurs in large numbers in the Marshall Islands, but populations of this species are apparently subject to wide fluctuations in abundance. Constraints on the use of this species are: present methods of capture used by U.S. fishermen are relatively ineffective; seasonal abundance and availability are poorly known, as well as basic life-history parameters upon which to base management methods; it is a food species for the Marshallese in some areas.

Recreational fish species: This group is briefly mentioned because it is not covered by the Hawaiian Recreational Fisheries Plan. The potential for development of the deep sea, lagoon, and reef sport fisheries in American Samoa, the Trust Territory, and Guam is well

known. The primary constraint in the development of some of the worlds' finest game fishing (and spearing) areas is the lack of support facilities. Obviously, the provision of these facilities is the role of local government and enterprise. However, it might be desirable for PR purposes for the NMFS to be associated with recreational fisheries development in the western Pacific through one or more small programs (e.g., provision of billfish tags to charter vessels).

Spiny lobsters: Although there are no indications of vast spiny lobster resources in the Trust Territory, the present ridiculously high prices of this commodity indicate that a harvest based on local fishermen selling their catches to a collecting freezer vessel might be feasible. The NMFS could serve as liaison between industry and officials of the Trust Territory and coordinate development efforts. An estimated potential annual harvest of 50-100 metric tons does not seem unreasonable.

THE ARMORHEAD (PENTACEROS RICHARDSONI) RESOURCE

Japanese and Russian vessels have been working the armorhead populations that inhabit the banks northwest of Midway for several years now. Production figures are not available, but the resource is extensive. Recent exploratory fishing catches by a Japanese research vessel produced about 480 metric tons during 32 days of fishing. Hauls of up to 17 metric tons per half-hour tow by the Russians have been reported to us.

It would seem that at present this resource would hold little interest for U.S. fishermen. Considering the remoteness of the fishing grounds and that the species is not visually appealing, it would seem that it will be some time before the domestic industry will consider this resource. However, it would be desirable for the NMFS to monitor the status of these stocks during the next decade.

TUNA BAITFISH WORKSHOP

Date: June 4-6, 1974

Place: Honolulu Laboratory
National Marine Fisheries Service

Sponsors: NMFS - Southwest Fisheries Center, Honolulu Laboratory
Sea Grant - University of Hawaii

BACKGROUND

The two principal methods of fishing commercially for tunas in tropical waters are by purse seining and pole-and-line fishing; the latter is commonly referred to as live-bait fishing.

One of the shortcomings of the live-bait fishing method is that it encompasses an added non-tuna fishing activity of requiring an adequate supply of baitfish. In many areas of the Pacific the stocks of naturally occurring baitfish are lacking or are only available in limited quantities; thus, the availability of baitfish has been a major limiting factor in the establishment of skipjack fisheries in many areas, or in areas where fisheries already exist, in the expansion of these fisheries.

An obvious solution to commercial fishing for skipjack tuna in the central and western tropical Pacific would be to turn to the purse seine method; however, based on field trials conducted to date, this method has not been sufficiently successful for commercial application. The general consensus is that the clear water and deep thermocline in the tropics make it possible for the skipjack tuna to dive beneath the nets before pursing has been completed; thus the rate of successful sets has been low. Further, the general erratic behavior of the skipjack schools in the tropics has also contributed to the low success rate achieved thus far with the purse seine gear. In view of the increasing demand for tuna and the potential high yields that the purse seine method represents, purse seine efforts in the tropics are continuing.

Even if purse seining were to meet with a measure of success in the tropics, the live-bait method of fishing will still have a role in local fisheries. Presently the island countries and territories of the Pacific are short on capital and technology, elements which are essential for the operation of a purse seine fishery. The purse seine method requires considerable capital outlay for vessels and gear; e.g., the cost of a modern purse seiner exceeds several million dollars and the cost of a net exceeds \$100.0 thousand. Also, the technology needed to operate a purse seine fishery appears to be of a level that participation by the island peoples would be limited under present-day conditions. Development of suitable technology would require time. Meanwhile the island governments are striving to find means of increasing employment opportunities for their citizens and of expanding their economic base today, and live-bait fishing for skipjack appears to meet these needs. In many areas, however, the implementation of live-bait fishing is dependent upon finding a reliable supply of baitfish.

The virtual lack of baitfish in the Line Islands area, American Samoa, Western Samoa, and the many atolls and high islands of the Pacific has retarded the development of skipjack fisheries in these areas, although skipjack are known to occur in these waters. In Hawaii and the Western Carolines (the Palau skipjack fishery) the supply of baitfish has been only sufficient for the operation of small fleets of tuna vessels; the annual landings of these fisheries average about 5.0 thousand tons. The Japanese southern fishery for skipjack tuna in the western Pacific is solely dependent upon the transport of baitfish from the home islands.

The several methods of meeting the baitfish needs of a tuna fishery are (1) natural stocks of baitfish, (2) culture of baitfish, (3) transshipment of natural or cultured baitfish from areas of abundance to areas of need, and (4) baitfish substitutes, e.g., inanimate material.

As the world demand for tuna increases and governments in the Pacific and elsewhere seek to develop or expand their fisheries for skipjack tuna, effort to resolve their baitfish problems assumes priority consideration.

PROBLEM

In areas where baitfish species are available, the question arises as to the size of a fishery that the baitfish resource will support. In areas where naturally occurring baitfish are in short supply or lacking, the question arises as to which of the several alternative plans should be implemented. In the field of cultured species, there is a need for a reassessment of this activity based on a thorough evaluation of past studies. Past field experiments with cultured species have been unsuccessful or have met with only limited success. Were these trials adequate? Is there a future in cultured species as a tuna baitfish? If so, where should future activities be focused? Finally, in areas where several options are available, there is a need to examine the economics of each option.

PROPOSAL

An in-depth study of the entire baitfish problem, especially as it relates to skipjack tuna fishing activities in the Pacific, should be undertaken to provide insight on the optimal strategy to follow. The presently conceived workshop should meet this need.

The objectives of the workshop are to (1) determine if suitable criteria of a good tuna baitfish can be identified, (2) review in depth the several alternative methods of meeting the baitfish needs of the various areas in the Pacific, (3) examine the economics of each of the alternatives, and (4) provide recommendations on the direction of future research activities, including the identification of priorities.

The tentative schedule is:

Tuesday (4 June 1974)

AM Opening sessions.

Establish criteria of good baitfish species.

PM Session meetings (natural stocks, cultured species, baitfish transport - baitfish substitutes, and economics)

Wednesday (5 June 1974)

AM Session meetings.

PM Session meetings.

Thursday (6 June 1974)

AM General meeting--review and discussion of session results.

PM Wrap-up.

The prepared papers and results of the workshop will be published.

3/22/74

SUMMARY
TUNA BAITFISH WORKSHOP

OBJECTIVES

1. Establish criteria of good tuna baitfish species.
2. Examine alternative plans of meeting baitfish needs:
 - a. Natural stocks
 - b. Cultured baitfish
 - c. Baitfish transport
 - d. Baitfish substitutes
3. Examine economics of alternative baitfish plans.

POTENTIAL PARTICIPANTS FOR WORKSHOP SESSIONS

1. Natural stocks
Kearney, Muller, Takata, Tester, Wetherall, P. Wilson, Yoshida
2. Cultured baitfish
Baldwin, Bardach, Fujimura, Gopalkrishnan, Hida, Iversen, K. Kato, Puffinburger, Shomura, Swerdloff, (a specialist in freshwater fish culture)
3. Baitfish transport - baitfish substitutes
Evringham, Gooding, Goto, Green, Hester, Otsu, Uchida, Yuen
4. Economics
Comitini, Kerns, Rothschild, Sheng
5. Others
J. Ball, J. Davidson, Brian Mar (or equivalent talent), E. Oswald

A Summary of the Pacific Ocean Skipjack Tuna Fisheries
and a Description, Evaluation,
and Distribution of the Principal Baitfishes.

By

Wayne J. Baldwin¹ and Thomas S. Hida²

INTRODUCTION

The worldwide annual skipjack tuna, Katsuwonus pelamis, landings since 1966 have been about 300,000 metric tons (FAO, 1972). About two-thirds of the world's catch have been made in the north-western Pacific by Japanese skipjack tuna vessels, and most of the remainder has been taken in the American eastern Pacific skipjack tuna fishery. The yellowfin tuna, Thunnus albacares, bigeye tuna, Thunnus obesus, and the albacore, Thunnus alalunga, are probably being harvested at near peak levels with the existing gear and fishing methods but skipjack tuna are considerably underutilized (Rothschild and Uchida, 1968; Kawasaki, 1972). Rothschild and Uchida (1968) estimated the potential yield of skipjack tuna in the central Pacific to be in the 100,000's of tons and Hester and Otsu (1973) reported Japanese estimates of the potential yield of skipjack tuna in the Pacific to be as high as 1.5 to 2.0

¹Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI 96744. Authored the section on the baitfishes.

²Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812. Authored the section on the skipjack tuna fisheries.

This is a draft report distributed for information only in connection with the Tuna Baitfish Workshop. It will not be published in the present form and should not be cited in the literature.

A Review on the Use of Live Baitfishes to Capture
Skipjack Tuna, Katsuwonus pelamis, in the Tropical Pacific Ocean
With Emphasis on Their Behavior, Survival, and Availability¹

WAYNE J. BALDWIN²

ABSTRACT

The use of live baitfishes in the Pacific Ocean skipjack tuna fishery is reviewed primarily to provide essential information for future baitfish investigations and as a useful reference for fishery development. Emphasis is placed upon various baitfish characteristics such as size, coloration, body form, behavior, schooling, survival in captivity, and their suitability for capturing skipjack tuna, Katsuwonus pelamis, by pole-and-line methods. In addition, data on their capture and handling methods are given. Thirty-one baitfish families are included in the text and pertinent information on each family is summarized in two appendix tables. A total of approximately 160 baitfish species are discussed in the text and their area of geographical use recorded in an appendix table and map of the Pacific Ocean. Recommendations for future research related to the use of baitfishes and an extensive bibliography are included.

¹Hawaii Institute of Marine Biology Contribution No. ____.

²Hawaii Institute of Marine Biology, University of Hawaii,
Honolulu, Hawaii 96822.

A Commercial Tilapia, Tilapia mossambica, Hatchery
for the Hawaiian Skipjack Tuna, Katsuwonus pelamis,
Fishery--A Cost Analysis and Problematical Study

BRUCE L. CRUMLEY

¹ Southwest Fisheries Center, National Marine Fisheries Service,
NOAA, Honolulu, HI 96812.

ABSTRACT

The Hawaiian skipjack tuna fisherman spends a good part of his time catching nehu, Stolephorus purpureus, for bait instead of fishing. This paper considers pond-raised tilapia, Tilapia mossambica, as a possible alternative bait, and sets forth information about a commercial tilapia production plant. If the fishermen purchased tilapia and fished full time, their bait would cost less than it does now, since the current break-even cost to the fisherman of a bucket of nehu is determined to be \$30.12, while the highest cost estimate for pond-reared tilapia is \$17.56.

Southwest Fisheries Center Administrative Report No. 15H, 1974

Experiences with Baitfish Transport Via Tanker-Trailer on Roll-On/Roll-Off
Freighter

By

Roger E. Green, Donald C. Aasted, Reginald M. Gooding¹

The following abbreviated diary account of the baitfish transport project is offered as a discussion guide only. Unfortunately, the authors' day-to-day involvement in the project up to and including the time of the workshop, left no time for them to prepare a more detailed paper.

First Shipment

- April 1 5,000 gal. tanker-trailer shipped from Honolulu. Aasted accompanied. Water tests of system 400 gpm.
- April 6 Tank arrived Los Angeles. Start dock-side experiments.
- April 6-7 Simulating ship's sea water system at dock but only 100 gmp with pump we rented.
- April 8 (AM) Est. 550 lb. put in tank.
- (PM) 588 lb. dead (siphon-cleaning).
- April 9 242 lb. dead.
- April 10 238 lb. dead. Tank cleaned. Total 1,068 lb.
- April 11 Second dock experiment. Est. 350 lb. put in tank.
- April 13 5 lb. dead on top-screens. Have not yet siphoned for dead.
- April 14 Siphoned. 71 lb. dead.

¹Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.

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April 15 21 lb. dead.
Four hours on closed system and 1/2 hour on stagnation.
No apparent ill effects. Dumped load and weighed live
fish. 179 lb. = 64% survival.

April 16 Third load of fish est. 550 lb. Destined for shipment.

April 17 40 lb. dead.

April 18 Left on Matsonia with Gooding at 1100 after all night
delay at Matson Terminal. Removed 54 lb. dead from
surface during crossing (no siphoning).

April 22 Arrived Honolulu. Made closed system transit to Kewalo
Basin. Removed 51 lb. from bottom. Dropped water level
and bucketed fish into 13,000 gal. holding tank (plastic
pool). Total dead--145 lb. Should have 405 lb. left,
but only 180 lb. est. remaining. Given to fishing boat
18 days later--no mortality in storage. Installed
permanent bottom siphon for continuous cleaning.

Second Shipment

May 8 Tanker-trailer shipped from Honolulu.

May 12 Tanker-trailer arrived Long Beach.

May 13-14 Setting up at dock side. New pump delivers 360 gpm.

May 15 Est. 1,600 lb. loaded in tank at new loading location--
closed system. Returned to Battelle dock and went on
open system. 119 lb. dead (some alive).

May 16 Removed siphon arrangement and enlarged siphon intake
slots. These were plugging up causing overflows.
308 lb. dead (some still living).

May 17 171 lb. dead (some still living).

May 18 368 lb. dead (some still living). Added 510 lb. (est.).

May 19 217 lb. dead (some still living). Put tanker with
Gooding on Matsonia about 2:30 PM with minimal delays.
310 lb. lost in transit.

May 23 Tank arrived Honolulu--new Sand Island Terminal.
Muddy water stirred up from bottom by tug. Distressed
fish. Oxygen dropped from 6-4 ppm. Oxygen added.
No mortalities from this. Transferred fish to storage
tank--Kewalo. Estimated 500 lb. left. Should have had
617 lb. based on original estimate.

May 25-27 Gave fish to two fishing boats.

May 28-June 3 Further modifications to vacuum-siphon system to reduce
live fish loss.

Third shipment

June 3 Tanker-trailer shipped from Honolulu.

The Economics of Baitfish Transport
Between California and Hawaii Using Tanker-Trailer
Aboard Roll-On/Roll-Off Freighter

By

Roger E. Green¹ and Paul Callaghan²

The following series of tables were prepared in haste and with the benefit of a scant 2 months' experience in the business of the subject. They are intended, not as "The Word," but as a basis for discussion at the Baitfish Workshop. Roger Green supplied the basic information and guesses concerning costs, labor, mortality percentages, etc. Paul Callaghan did the work.

¹Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.

²Graduate Student, Economic Research Center, University of Hawaii, Honolulu, HI 96822.

This is a draft report distributed for information only in connection with the Tuna Baitfish Workshop. It will not be published in the present form and should not be cited in the literature.

Gear, Methods and Facilities Used in Several
Bait Fisheries in the Pacific

By

Thomas S. Hida¹

An adequate and steady supply of live bait is essential to the success of a pole-and-line fishery for tunas. The Japanese western Pacific and the American eastern Pacific tuna fisheries utilize the greatest amount of live bait. The live-bait, pole-and-line tuna fisheries in Hawaii, Ryukyu, Philippine, Palau, Papua New Guinea, Australia, and New Zealand and a few other areas utilize smaller quantities of live bait. This paper describes briefly the gear, methods, and facilities that are used in these Pacific areas.

Japanese Western Pacific Bait Fishery

The Japanese live-bait, pole-and-line fishery for skipjack tuna, Katsuwonus pelamis; yellowfin tuna, Thunnus albacares; and albacore, T. alalunga, now utilizes about 20,000 metric tons of anchovies as live bait annually. The anchovy, Engraulis japonica, constitutes about 97% of the live bait used. Previously, the sardine, Sardinops melanosticta, was the predominant species used. The use of the scad, Decapturus muroaji, and juveniles of the

¹Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.

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Biology of the baitfishes Herklotsichthys punctatus
and Prionosus ^{pignus} ~~pignus~~ in Majuro, Marshall Islands

THOMAS S. HIDA and JAMES H. UCHIYAMA¹

¹Southwest Fisheries Center, National Marine Fisheries Service,
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ABSTRACT

The results of a baitfish scouting and sampling program carried out in the lagoon of Majuro Atoll, Marshall Islands, from May 1972 through April 1973 are presented in this report. The distribution and abundance, age and growth, maturity and fecundity, and stomach contents of the major baitfishes, Herklotsichthys punctatus (sardine) and Pranesus pinguis (silverside), are discussed. Adequate samples of baitfish could not be collected because of the apparent absence of suitable concentrations of the two major bait species, whose abundance fluctuated widely during the period of the observations.

What Constitutes a Bucket of Live Bait in the Hawaiian
Pole-and-Line Fishery for Skipjack Tuna, Katsuwonus pelamis

By

Thomas S. Hida and Jerry A. Wetherall¹

There are many estimates of live-bait buckets and scoops in the various live-bait, pole-and-line fisheries for skipjack tuna, Katsuwonus pelamis, in the Pacific. It becomes apparent that if these estimates are to be used to assess the baitfish stocks or in baitfish economic studies, we have to define more precisely what constitutes a bucket or scoop of live bait. Therefore, it was thought necessary to define a bucket of live bait for the Hawaiian skipjack tuna fishery. Many researchers have used 3.2 or 3.6 kg (7 or 8 pounds) as the weight of the anchovy or nehu, Stolephorus purpureus, in a bucket of live bait in their studies of the Hawaiian pole-and-line fishery for skipjack tuna. No information on the methods by which their figures were derived nor a good description of a bucket were given.

Up until the mid-1960's, the bait was bucketed from the bunt of the net into the live baitwells of the skipjack tuna fishing vessels. Since then, several vessels have been dipnetting the bait from the bunt of the net into buckets and then placed into the baitwells--this information was given by several fishermen who were interviewed.

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This is a draft report distributed for information only in connection with the Tuna Baitfish Workshop. It will not be published in the present form and should not be cited in the literature.

June 4-6, 1974, Honolulu, Hawaii

Southwest Fisheries Center Administrative Report No. 20H, 1974

A REVIEW OF CATCH AND EFFORT STATISTICS
IN FISHERIES FOR LIVE BAIT IN THE PACIFIC OCEAN

By

Richard N. Uchida

INTRODUCTION

This paper presents a brief description of the pole-and-line and live-bait fisheries in the eastern, central, and western Pacific and reviews the historical catch and effort statistics that were collected in fisheries for tuna baitfishes. A review of the statistical system is also included.

EASTERN PACIFIC FISHERY

The eastern Pacific tropical tuna fishery under the present fleet composition is essentially a purse-seine fishery, but prior to 1959, the fishery was predominantly a live-bait fishery. In 1948, of 118,752 M.T. of skipjack, Katsuwonus pelamis, and yellowfin, Thunnus albacares, landed by the eastern Pacific fleet, about 84% were caught by baitboats. By 1960, the proportion of the tunas taken by baitboats dropped to about 40% as the "purse seine revolution" launched a mass conversion of baitboats to seiners. In recent years, only about 10% of the tunas are landed by baitboats. Table 1 shows the number of baitboats and seiners operating in the eastern Pacific in 1950-72.

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The Fishery for Nehu, Stolephorus purpureus, a Live Bait
Used for Skipjack Tuna, Katsuwonus pelamis, Fishing in Hawaii

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ABSTRACT

With increasing interest in the baitfish resources and their capacity to support local skipjack tuna, Katsuwonus pelamis, fisheries, we need to evaluate their distribution and relative abundance. This paper describes the trends in production of nehu, Stolephorus purpureus, an anchovy used as live bait in the fishery for skipjack tuna in Hawaiian waters.

Kaneohe Bay and Pearl Harbor, two of the most important baiting sites in the Hawaiian Islands, produce 71% of the bait. Another important site on Oahu, particularly for night baiting, is Kalihi-Keehi Lagoon.

Day baiting produced 79% whereas night baiting produced 21% of the State's nehu catch. Catches and baiting effort showed a downward trend in the day fishery and an upward trend in the night fishery in 1961-65. In 1966-72, however, catches and baiting effort increased steadily in the day fishery whereas they declined in the night fishery.

Catch Statistics and the Abundance of Nehu,
Stolephorus purpureus, in Kaneohe Bay

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Catch Statistics and Abundance of Nehu,
Stolephorus purpureus, in Kaneohe Bay

Jerry A. Wetherall

Suggested Abstract

Catch and nominal effort statistics from the Kaneohe Bay day-baiting fishery for nehu, Stolephorus purpureus, were used to explore hypotheses concerning two sources of variation in baiting success: 1) nehu stock abundance and 2) abiotic environmental variables. Baiting success was found to be positively correlated with streamflow in a major tributary to Kaneohe Bay, but was unrelated to nominal baiting effort. However, the assumptions underpinning the analyses cannot be accepted with confidence, because the available nominal effort data do not provide a good measure of effective baiting effort. A definitive understanding of nehu stock dynamics will require changes in data collection practices of the Hawaii Division of Fish and Game. In particular, detailed information on catch per set of the bait seine and on size composition of the nehu stock and catch are needed.

TUNA BAITFISH WORKSHOP
June 4-6, 1974, Honolulu, Hawaii

WP/Gen/8

The Pacific Tuna Pole-and-Line Fisheries:

The Efficacy of Fishing With Live Bait

By

HOWARD O. YOSHIDA¹

ABSTRACT

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The Production of Tuna in the Eastern Pacific,
Hawaiian, and Japanese Pole-and-Line Fisheries

By

HOWARD O. YOSHIDA¹

INTRODUCTION

The catch statistics published by the Food and Agriculture Organization (FAO) (1971) indicate that the total landings of skipjack tuna, Katsuwonus pelamis, yellowfin tuna, Thunnus albacares, albacore, T. alalunga, and bigeye tuna, T. obesus, in the Pacific Ocean by all methods of fishing amounted to an estimated 702,600 metric tons in 1970. It is estimated that of these total landings 243,800 metric tons were made by the pole-and-line fishing method using live bait. The landings by the pole-and-line fisheries represent about 35% of the total landings by all methods of fishing. Thus, in spite of the technological advance made in the purse seine method as practiced in the eastern Pacific Ocean, the harvesting of tunas by the pole-and-line method still remains an important part of the tuna fisheries in the Pacific Ocean.

Of the several pole-and-line fisheries operating in the Pacific Ocean, the fisheries in the eastern Pacific (now dominated by the purse seiners) around the Hawaiian Islands and in Japanese

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The Utilization of Nehu, Stolephorus purpureus: A Potential
Conflict Among User Groups

By

Howard O. Yoshida¹

INTRODUCTION

The nehu, Stolephorus purpureus, a small (40-60 mm), fragile anchovy that schools in bays and harbors, is the most important native bait fish found in the Hawaiian Islands. The Hawaiian aku or skipjack tuna, Katsuwonus pelamis, pole-and-line fishery is entirely dependent on a supply of live bait and nehu accounts for about 92% of the bait utilization of this fishery (Yamashita, 1958). Although the nehu possesses most of the qualities of a good baitfish, there are some major problems associated with its use, among them being its short supply, particularly during the peak skipjack tuna fishing season from May to September. Indeed, one of the major factors limiting the development of the Hawaiian aku fishery to its full potential is the supply of live bait.

The commercial aku fishery is, by far, the largest user group of the nehu in Hawaii. Over the years, various researchers have attempted to put a value on nehu relative to the commercial

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aku fishery. Most recently, Yamauchi and Afifi (in press) imputed a dollar value of the nehu bait fishery in Kaneohe Bay, one of the major baiting sites in the Hawaiian Islands, ranging from \$350,000 to \$660,000 annually. Since Kaneohe Bay on the average accounts for about one fourth of the total nehu production of the State, the total State value of the bait fishery for nehu would be four times that of Kaneohe Bay or from \$1,400,000 to \$2,640,000. By comparison, figures published by the Hawaii State Division of Fish and Game show that the commercial fish landings in Hawaii in 1972 were valued at \$5,747,103.

Other user groups of nehu are recreational fishermen, who use nehu as bait for sport fishing, takers of nehu for "family consumption," and commercial fishermen who use nehu to catch fish other than skipjack tuna. All these users of nehu, in contrast to the commercial aku fishery, do not require that the nehu be alive and their total requirement probably constitutes only a small percentage of the total utilization of nehu.

It would be well here to review briefly what the laws and regulations of the State of Hawaii provide with regard to the nehu. The regulations of the Division of Fish and Game of the Department of Land and Natural Resources provide that bait permits be issued to commercial fishermen for the taking of certain fishes, including the nehu. The regulations further state that, "bait permits shall be issued to persons engaged in catching bait fish for use as bait in fishing operations where

the fish caught are landed in the State and no baitfish caught under a bait license shall be sold or transferred except for such purpose." Furthermore, "it shall be unlawful to take nehu for commercial bait purposes except by permit issued by the Division of Fish and Game of the Department of Land and Natural Resources," and "all persons holding bait permits shall file catch reports with the Division of Fish and Game." However, "all persons may take nehu for family consumption, provided, however, that only one gallon per person per day may be taken and no net longer than twenty-five feet may be used." The term "family consumption" is defined as "the taking of nehu for any purpose other than for use as bait by a licensed commercial fisherman." Thus, the takers of nehu for family consumption require no bait permit. Finally, it is unlawful at anytime to sell, offer for sale, or trade dried or cured nehu.

THE PROBLEM

Nehu has probably been used as bait to catch aku since the very beginning of the fishery. Cobb (1903) gives an account of the techniques used by the native Hawaiians for catching aku, including the practice of the use of nehu as live bait. Because of the long tradition of the use of nehu as bait, the local aku fishermen have come to view the nehu resource in a proprietary manner and resent the intrusion of other user groups. Recently, there apparently has been an increase in the number and types of

user groups, including groups allegedly catching and illegally selling nehu. An associated problem is that these user groups roil the waters and scatter the nehu while catching bait, thus making it difficult for the aku fishermen to catch bait. This problem is apparently most acute in Kaneohe Bay, Oahu where the aku fishermen have complained about certain other user groups of taking "considerable amounts" of nehu.

Because of the increased number of different user groups and an apparent increased demand on the nehu resource, there is a need for an updated study to determine if the present utilization of nehu exceeds levels considered good for proper management. The results of this study should determine if there is a need to develop a suitable management scheme. Regardless of the status of the nehu resource, there is a problem now with a potential conflict among the various user groups. The purpose of this report, then, is to present some options to the solution of the problem of the potentially critical conflict among user groups so that the highest and best utilization of the nehu resource can be realized, and to review rather superficially the status of the nehu resource.

THE NEHU RESOURCE

The nehu is generally found in certain brackish, turbid inshore waters of most of the major islands in Hawaii and their relative abundance in various localities is limited by the presence of suitable environmental conditions. The annual total State catch of nehu from 1948 to 1972 is shown in Figure 1. During this period the annual catch of nehu fluctuated from a low of 23,622 buckets² to a high of 49,712 buckets and averaged 36,195 buckets. There appeared to be no clear trends, upward or downward, in the catches. In Figure 1 are also shown the number of active aku boats and the CPUE (catch per unit of effort) of nehu, in terms of catch per boat from 1948 to 1972. It can be seen that the number of aku boats in the State declined from 1955 to 1972. The CPUE for nehu, however, showed a generally increasing trend during the same period. Therefore, it appears that although the number of boats was declining, the individual boats were able to catch more nehu so that no declining trend in total catches were evident. It should be pointed out, however, that there is some evidence to suggest that the nehu in the different baiting sites throughout Hawaii comprise discrete subpopulations and do not intermingle to any great degree (Tester and Hiatt, 1952). Therefore the total State catch of nehu may not reflect the true condition of the nehu populations in the various baiting sites.

The relative importance of the islands of Oahu, Maui, Hawaii, and Kauai in terms of nehu production from 1948 to 1972

1 is shown in Table 1. It can be seen that, by far, Oahu was the most important bait producer among the four islands. The reason for this is most likely because of the greater availability of habitats suitable for nehu on Oahu. Between 1948 and 1972, 41% to 90% (mean of 68%) of the nehu catches by aku fishermen were made on Oahu. In the last 7 years (1966 to 1972) 83% to 90% (mean of 87%) of the catches were made on Oahu. It appears that in more recent years the aku fishermen have come to rely more on the bait supply on Oahu than on the neighboring islands. One contributing factor to the small amount of nehu presently being taken on the other islands is the fact that the number of boats based on these islands, which has always been small, is at present even smaller (see Table 1). In order of relative importance Maui follows Oahu, then Hawaii and lastly Kauai. Principal baiting sites on Maui are Maalaea Bay and Kahului Harbor; on Hawaii, Hilo Harbor and Kawaihae Harbor. The small amounts of nehu produced on Kauai are taken mostly at Nawiliwili and Hanapepe.

2 Because of the importance of the island of Oahu in the total State production of nehu, it is well to consider the status of the nehu resource on Oahu in greater detail. Table 2 shows the relative importance of the various baiting sites on the island of Oahu from 1948 to 1972. By far the most important baiting sites were Kaneohe Bay and Pearl Harbor. During the period from 1948 to 1972 Kaneohe Bay and Pearl Harbor produced, on an average,

78% of the nehu caught by the aku fishermen on Oahu. All the rest of baiting sites combined produced 22%. It can be seen in Table 2, however, that the fraction of the annual total Oahu production of nehu contributed by any of the various baiting sites experienced wide fluctuations during this period. For example, the annual fraction produced by Kaneohe Bay from 1948 to 1972 varied from 13% to 84% of the Oahu total. The interrelationships of these annual fluctuations within a particular baiting site and among the various other sites are probably complex and will not be discussed here.

The annual catches of nehu from 1948 to 1972 in Pearl Harbor and Kaneohe Bay are shown in Figure 2. Bachman (1963) noted a periodicity in the relative abundance of nehu on Oahu during the period from 1948 to 1960. He noticed a peak in relative abundance every 2 or 3 years. The annual catch of nehu between 1960 and 1972 also showed some sort of cycle in abundance, particularly in Pearl Harbor. The important point here is that there seems to be no declining trend in the catches of nehu in Pearl Harbor and Kaneohe Bay over the years. However, the large catches of nehu made in Pearl Harbor in 1971 and 1972 should be of some concern. Bachman (1963), using the Schaefer (1957) method, determined that the maximum sustained yield of nehu in Pearl Harbor was 18,620 buckets with an effort of 691.5 boat days. In 1971, the catch of nehu in Pearl Harbor was 18,834 buckets with 687 days of effort (R. N. Uchida, Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812, pers.

comm.) It should be pointed out here that whether Bachman's "boat-days" is comparable with the effort in terms of "days" is not known.

The situation in Kaneohe Bay is somewhat different from that in Pearl Harbor. Bachman (1963) found that Schaefer's (1957) method could not be used to determine the maximum sustained yield of nehu in Kaneohe Bay because there was a "population resiliency" within the fishery, and up to the time of his study, enough effort had not been expended to make a difference in the nehu population. The annual catch statistics shown in Figure 2 do not indicate any serious problems with the nehu population in Kaneohe Bay at present.

Up to this point the nehu resource has been discussed primarily as it relates to the commercial aku fishery. As noted earlier, however, there are other user groups utilizing the nehu resource. These other user groups apparently restrict their nehu catching activities primarily to Kaneohe Bay on Oahu. One reason for this is because of Kaneohe Bay's easy accessibility to all user groups. Indeed, Kaneohe Bay is one of the more popular recreational areas on Oahu and a large number of different activities are carried out in its waters (Yamauchi and Rutherford, in press).

For resource management purposes it would be useful to determine the total catch of nehu, including those catches made by the other user groups. It is difficult, however, to document

the catches of nehu made by the other user groups. It was noted earlier that a license was not required for takers of nehu for family consumption, and these non-licensed users were not required to submit catch reports. Takers of nehu for family consumption presumably include people catching nehu for table food and recreational fishermen who use nehu as bait in sport fishing.

Some data are available for commercial fishermen other than aku fishermen who catch nehu for use as bait. These fishermen fish the inshore waters with handlines for fish such as omaka, Caranx mate, hahalalu, Trachurops crumenophthalmus, opelu, Decapterus pinnulatus, and weke, Mulloidichthys samoensis. Statistics compiled by the Hawaii Division of Fish and Game show that these fishermen took 553 buckets of nehu from January to November of 1973. The mean annual catch of nehu made by the aku fishermen in Kaneohe Bay from 1948 to 1972 was 10,472 buckets. Thus, in the 11-month period of 1973 the other commercial fishermen took approximately 5% as much bait taken annually, on the average, by the aku fishermen.

Although the nehu catch statistics for Kaneohe Bay are incomplete in that they do not include the catches of all the user groups, it appears that, superficially, the nehu population is not in bad condition. That is, if the nehu population was in distress, this condition should be indicated in the catches made by the aku fishermen. As noted earlier, Bachman (1963) suggested that the nehu in Kaneohe Bay (up to 1960) had a "population resilience" and that fluctuations in apparent abundance were not

fishery related. More recent data indicate that the fishing pressure, including that of other user groups, still has not made a marked effect on the nehu population in Kaneohe Bay.

There is still a need, however, to update Bachman's (1963) study. The fact that the catch of nehu in Pearl Harbor in 1971 and 1972 exceeded or came close to the maximum sustained yield, as determined by Bachman, should be of some concern. The accuracy of Bachman's estimate should be evaluated. The maximum sustained yield of nehu in Kaneohe Bay should also be determined. Finally, further studies on the interrelationships of the nehu populations in the various baiting sites throughout the State should be instituted. The results of this study should have important implications in the management of this valuable resource.

POSSIBLE SOLUTION TO THE PROBLEM OF USER CONFLICTS

Any possible solution to the problem of user conflicts must consider the viewpoints and demands of all the user groups. Should regulations and laws governing the utilization of the nehu be promulgated based purely on economic considerations or are other less well-defined values just as important? That is, how does one determine which user group has the greater vested interest in the nehu resource. This is difficult to determine even on a purely economic basis. It has been pointed out that the value of the nehu resource has been estimated at \$1,400,000 to \$2,640,000 to the commercial aku fishermen. Comparable figures for commercial fishermen other than aku fishermen are not available. These handline

fishermen use nehu as bait to catch hahalalu, omaka, opelu, and weke. The quantity of nehu used by these fishermen is not known. However, the value of the landings of these species landed by the handline fishermen amounted to about \$116,912 in 1972. With information on all the necessary variables, economists could probably impute values on nehu to these fishermen also.

The value of nehu to those who catch nehu for table food is even harder to determine, one reason being that no catch statistics are available for this user group. The monetary value of the catch, however, is probably minimal.

Similar to the other user groups, catch figures of nehu for recreational fishermen are not readily available. It would be useful to determine the quantity of nehu utilized by recreational fishermen on which economists could impute values. Although the amount spent for all bait may not be great the total expenditure by recreational fishermen to pursue their hobby appears to be considerable. Hoffman and Yamauchi (1972) studied recreational fishing in Hawaii and stated that while no purposeful comparisons of recreational and commercial fishing was attempted, "all indications point to the confirmation of the feelings of many including the members of the 1967 Governor's Marine Advisory Panel, that the recreational fishing sector provides greater benefits to Hawaii than the commercial fishing sector."

Another factor to consider in the solution of the problem is that there is a need to institute management measures to regulate the taking of nehu so that more efficient use is made of this valuable resource. For example, the following situation should be considered. The aku fishermen spend considerable time searching for and catching nehu needed to fish aku. This is valuable time which could be more profitably put to use fishing for aku. The baiting operations are made more difficult and take considerably more time when other user groups roil the water and scatter the nehu. The problem becomes more serious during the peak aku season from May to September when the demand for bait increases and the aku boats must compete not only with each other for bait but with these other user groups. Another important point to consider is that the aku fishery requires live bait whereas for all the other user groups live nehu is not a requirement.

What are some of the options in solving the problem of conflicts among user groups and at the same time provide for the highest and best utilization of the nehu resource? Several options are suggested below. These options are not mutually exclusive. Perhaps a combination of two or three of those suggested may work to solve the problem.

One option would be to raise the fee for a bait permit high enough to discourage "spurious" users of nehu. This should eliminate those commercial fishermen who do not really need nehu

but use it because it is available. This action, however, will not exclude the other user groups like the takers of nehu for family consumption and recreational fishermen since no permit is required of these user groups. Thus, the problem of the roiling of the water and the scattering of nehu schools would not be solved.

Setting catch limitations for the other user groups (family consumption, recreational fishermen and other commercial non-aku fishermen) may prevent "excessive" amounts of bait to be taken by these groups but again will not solve the "roiling" and "scattering" problems. Then, too, this may not be equitable to these groups.

Restricting the privilege of catching nehu exclusively to aku fishermen either throughout the entire year or during May to September when the need for nehu by the aku fishery is greatest will presumably solve the aku fishermen's problems. However, this option will not make the highest and best use of the nehu because other user groups will not have access to nehu during part or all of the year.

An option that perhaps will be acceptable to all user groups would be one that will allow only the aku fishermen to catch nehu together with some stringent stipulations on the aku fishermen. These stipulations would be that for the exclusive privilege of catching nehu the aku fishermen will be required to save and preserve by salting all the nehu that die during

their baiting and fishing operations. Furthermore, that the salted nehu would be made available, perhaps through some middle men, at nominal cost and at convenient outlets to all users. Also, there should be a guarantee that the other user groups will have access to a certain amount of nehu on an annual or some other basis.

This option will eliminate the "roiling" and "scattering" problem and still make nehu available to all user groups. It also has other benefits. Table 3 shows the amount of nehu caught and the amount actually used in fishing operations by the aku fishermen from 1963 to 1972. The difference between the amount caught and used is presumed to be the quantity of nehu that die and are discarded by the aku fishermen. During this 10-year period the amount of nehu that died and was discarded amounted to an average of 30% of the amount that was caught, or an average of 10,199 buckets. It could well be that 10,199 buckets ^{32.4 metric tons or} ~~71,393~~ pounds) of nehu may fulfill the needs of all the other user groups. The nominal amount charged for the bait should defray the operating costs of maintaining this system. And good use will be made of the nehu that are now usually discarded.

The recreational fishermen will probably be happy to pay a nominal sum for salted nehu to use as bait. The commercial fishermen (other than aku fishermen) should also be agreeable to purchasing nehu. This will eliminate valuable time spent catching

their own bait--time that could be more profitably put to use catching income-producing fish. And users of nehu for table food would most likely be willing to pay a nominal price for nehu.

In summary, the solution to the problem of conflicts among user groups must incorporate provisions for the highest, best, and most efficient use of the valuable nehu resource. It would appear, then, that the aku fishermen should be allowed to catch nehu without the interference of the other user groups. This should make their operations more efficient by reducing time spent baiting. By the same token, all the nehu that are not utilized by the aku fishermen after being caught, i.e., all the bait that die during baiting and fishing operations, should be saved for the utilization of the other user groups. These actions will maximize the operating efficiency of the aku fishery and other user groups and also make better utilization of the nehu resource for all the user groups.

LITERATURE CITED

BACHMAN, R.

1963. Fluctuations and trends in the abundance of nehu (Stolephorus purpureus Fowler) as determined from catch statistics. M.S. Thesis, Univ. Hawaii, Honolulu, 100 p.

COBB, J. N.

1903. The commercial fisheries of the Hawaiian Islands. Bull. U.S. Fish Comm. 23, Pt. 2:717-765.

HOFFMAN, R. G., and H. YAMAUCHI.

1972. Recreational fishing--its impact on State and local economies. College of Tropical Agriculture, Hawaii Agricultural Experiment Station, Univ. Hawaii, Departmental Paper 3, 38 p.

SCHAEFER, M.B.

1957. A study of the dynamics of the fishery for yellowfin tuna in the eastern tropical Pacific Ocean. Bull., Inter-Am. Trop. Tuna Comm. 2:247-285.

TESTER, A. L. and R. W. HIATT.

1952. Variation in the vertebral number of the anchovy, Stolephorus purpureus, in Hawaiian waters. Pac. Sci. 6:59-70.

YAMASHITA, D. T.

1958. Analysis of catch statistics of the Hawaiian skipjack fishery. U.S. Fish Wildl. Serv., Fish. Bull. 58:253-278.

YAMAUCHI, H., and H. AFIFI.

In press. The value of Kaneohe Bay as a bait fishery. In
Estuarine pollution in the State of Hawaii, Part II:
Kaneohe Bay study. Section B. Tech. Rep. 21:186-221.
Univ. Hawaii, Water Resour. Center.

YAMAUCHI, H., and F. RUTHERFORD.

In press. Recreation values of Kaneohe Bay. In Estuarine
pollution in the State of Hawaii. Part II: Kaneohe Bay
study. Section B. Tech. Rep. 31:222-256. Univ. Hawaii,
Water Resour. Center.

Table 1.--Relative Importance of Oahu, Maui, Hawaii, and Kauai in nehu production, 1948-72.

(Based on data from Hawaii Division of Fish & Game.)

Year	Oahu			Maui			Hawaii			Kauai		
	No. of boats	Fraction of State catch	No. of boats	No. of boats	Fraction of State catch	No. of boats	No. of boats	Fraction of State catch	No. of boats	No. of boats	Fraction of State catch	No. of boats
1948	18	0.57		5	0.28		2	0.12	--		0.03	--
1949	20	0.70		4	0.19		2	0.10	--		0.00	--
1950	18	0.61		5	0.30		2	0.08	2		0.01	2
1951	19	0.49		5	0.32		2	0.16	2		0.03	2
1952	19	0.51		5	0.29		2	0.17	2		0.03	2
1953	19	0.59		5	0.27		2	0.10	1		0.04	1
1954	18	0.49		4	0.24		3	0.22	2		0.05	2
1955	21	0.52		4	0.27		3	0.19	--		0.02	--
1956	20	0.65		4	0.21		2	0.13	--		0.01	--
1957	19	0.70		4	0.15		2	0.15	--		0.00	--
1958	16	0.65		6	0.18		2	0.15	--		0.01	--
1959	15	0.41		6	0.36		2	0.21	--		0.02	--
1960	12	0.57		7	0.23		2	0.15	--		0.04	--
1961	12	0.61		7	0.22		2	0.15	--		0.01	--

Table 1.--Continued.

1962	12	0.63	5	0.21	3	0.14	--	0.02
1963	12	0.69	5	0.20	3	0.11	--	0.00
1964	12	0.78	5	0.10	3	0.11	--	0.00
1965	14	0.77	2	0.09	3	0.13	--	0.00
1966	13	0.87	2	0.07	2	0.06	--	0.00
1967	14	0.87	2	0.07	2	0.06	--	0.00
1968	12	0.89	2	0.06	2	0.04	--	0.00
1969	12	0.88	2	0.10	1	0.02	--	0.00
1970	12	0.87	2	0.10	1	0.03	--	0.01
1971	11	0.83	2	0.14	1	0.04	--	0.00
1972	12	0.90	2	0.08	1	0.02	--	0.00
25-year mean		0.68		0.19		0.12		0.01
(1948-72)								
Last 7-year		0.87		0.09		0.04		0.00
mean (1966-72)								

Table 2.--Relative importance of various baiting sites on Oahu, 1948-72.

(Based on data from Hawaii Division of Fish & Game.)

Year	Fraction of total Oahu catch				Total Oahu catch (buckets)	
	Kaneohe Bay	Honolulu Harbor	Keehi Lagoon	Pearl Harbor		Other areas
1948	0.84	0.01	0.01	0.07	0.08	23,988
1949	0.58	0.04	0.02	0.34	0.02	27,660
1950	0.50	0.26	0.03	0.18	0.03	24,160
1951	0.52	0.18	0.03	0.25	0.01	19,901
1952	0.35	0.13	0.06	0.44	0.02	15,150
1953	0.40	0.16	0.05	0.35	0.03	21,997
1954	0.54	0.14	0.06	0.23	0.02	21,320
1955	0.48	0.09	0.04	0.35	0.04	25,775
1956	0.48	0.07	0.14	0.27	0.04	26,582
1957	0.25	0.11	0.09	0.54	0.01	21,401
1958	0.41	0.11	0.08	0.37	0.03	21,799
1959	0.29	0.20	0.17	0.30	0.04	15,615
1960	0.49	0.02	0.19	0.26	0.03	13,648
1961	0.40	0.10	0.08	0.30	0.12	22,872

Table 2.--Continued.

1962	0.32	0.10	0.16	0.31	0.11	21,707
1963	0.35	0.07	0.17	0.35	0.05	22,674
1964	0.13	0.11	0.27	0.43	0.06	25,131
1965	0.19	0.12	0.22	0.45	0.02	28,131
1966	0.45	0.08	0.21	0.24	0.02	27,500
1967	0.42	0.09	0.19	0.30	0.00	27,732
1968	0.49	0.03	0.07	0.38	0.03	31,755
1969	0.45	0.04	0.07	0.42	0.01	26,642
1970	0.56	0.04	0.07	0.33	0.01	29,003
1971	0.34	0.04	0.05	0.54	0.02	34,699
1972	0.41	0.01	0.05	0.52	0.01	35,216
25-year mean (1948-72)	0.43	0.09	0.10	0.35	0.03	
Last 7-year mean (1966-72)	0.44	0.05	0.10	0.40	0.02	

Table 3.--Utilization of nehu by the aku fishery.

(Data from Hawaii Division of Fish & Game.)

Year	Caught	Used	Mortality (caught-used)	Percent mortality
1963	32,787	23,628	9,159	27.9
1964	31,981	23,694	8,287	25.9
1965	36,384	28,315	8,069	22.2
1966	31,614	23,466	8,148	25.8
1967	31,932	21,264	10,668	29.7
1968	35,524	23,911	11,613	32.7
1969	29,721	18,833	10,888	36.6
1970	33,451	22,130	11,321	33.8
1971	41,928	30,691	11,237	26.8
1972	39,273	26,674	12,599	32.1
Total	344,595	242,606	101,989	
Mean	34,460	24,261	10,199	29.6

TEXT FOOTNOTE

²A bucket of bait is roughly equivalent to 7 pounds.

FIGURE 1--CATCH, EFFORT AND CUE OF WOLF IN HAWAII, 1948-1972.
 (CATCH PER BOAT, EFFORT IN BOATS, CUE IN BOATS)

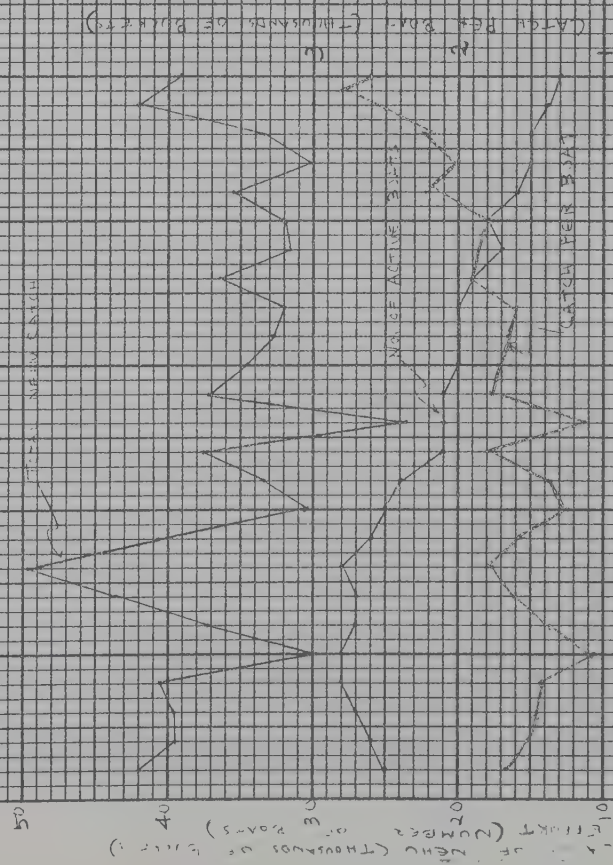


Figure 2 --

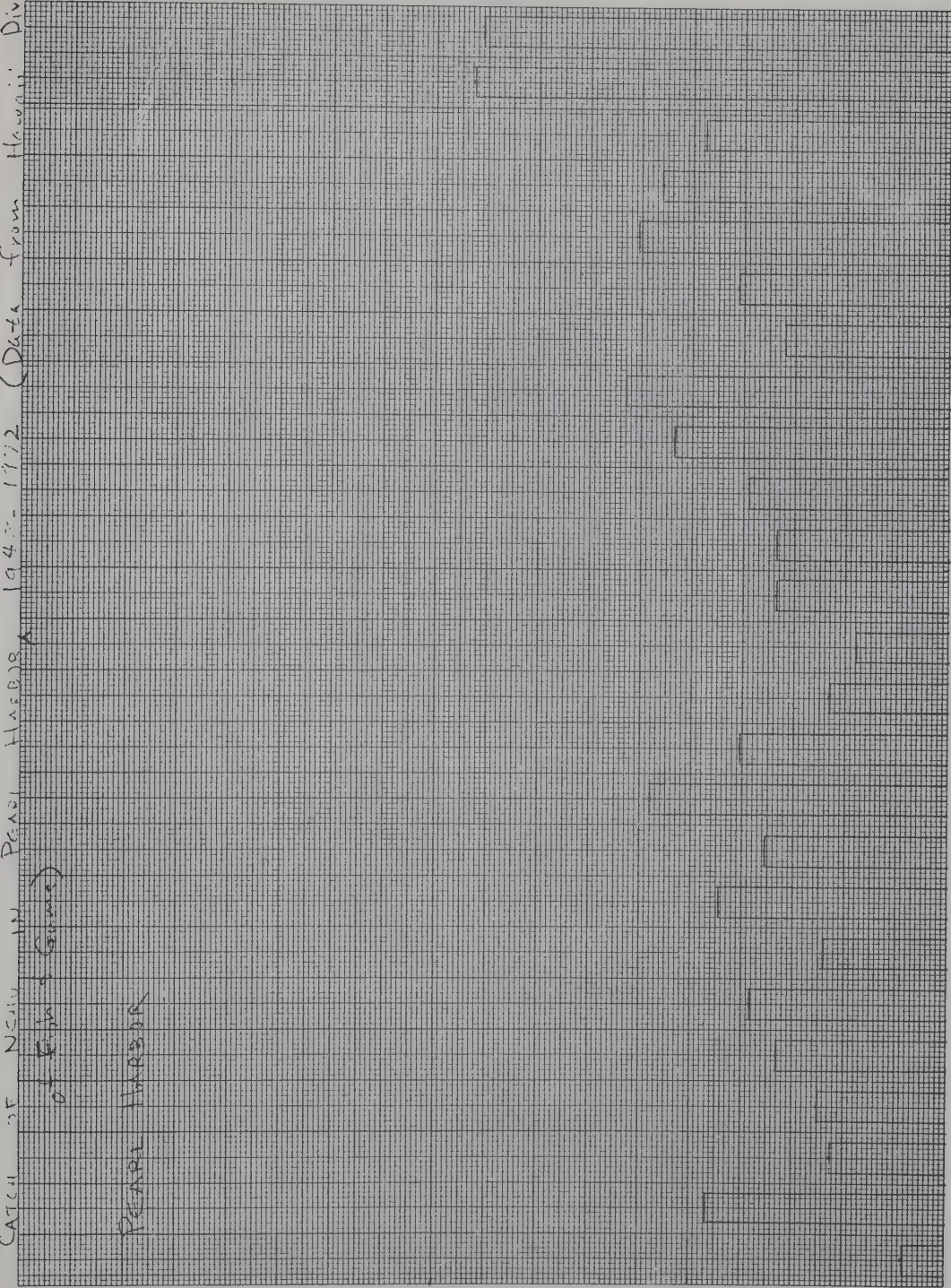
AND KANEHOE BAY

CATCH OF NEKTON IN PEARL HARBOR
(of Fish & Game)

1943-1972 (Data from Hawaii Division)

PEARL HARBOR

THOUSANDS
TICKETS TO



Catch 35 Nov 10 1948-1972

KANIGIE DAY

20

ROCK IS

10

01

THOUSANDS

1950

1960

1970

Desired Characteristics of a Bait for Skipjack Tuna

HEENY S. H. YUEN¹

ABSTRACT

Skipjack tuna, Katsuwonus pelamis, fishing in the central Pacific Ocean is largely dependent upon a limited supply of live baitfish, the nehu, Stolephorus purpureus. Experiments by the Honolulu Laboratory in a search for effective live bait substitutes or supplements have resulted in the collection of much information on behavioral characteristics of the experimental baits. Characteristics of an effective skipjack tuna bait are: a tendency to flee towards the surface, elusiveness, a high light reflectance, a length of 2-6 cm, and the durability to survive in a baitwell.

¹Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.

REPORT OF GENERAL SESSION

Criteria of Good Baitfish Species

Chairman : Richard S. Shomura (in place of Michio Takata)
Rapporteur: Howard O. Yoshida

A. References

WP/Gen/3, WP/Gen/10, WP/Gen/11, Ref/8

B. Discussion

As a starting point for the discussion, categories of characteristics important in a good bait species as found in species now being used as live bait in pole-and-line fisheries were enumerated. This list of categories, as adopted from a list contained in WP/Gen/10, included the following:

1. Availability
 - a. Natural stocks
 - b. Cultured stocks
2. Behavior when chummed at sea
 - a. Movement (erratic)
 - b. Attract and hold tuna schools
3. Survival in captivity (hardiness)
4. Fishermen acceptance
 - a. Handling
5. Color and color patterns
6. Body form
7. Size

The question of the relevancy of each of the categories listed was discussed in detail. The discussion also included points on the general qualities of a good baitfish. In this regard there was an objection to the use of the term "perfect" baitfish. Insofar as the qualities of a good baitfish was concerned, some of the points brought out were that some species had qualities that were good in certain ways but not good in others. For example, there are baitfish that initially attracted the tunas but were not good in holding the fish at the boat. A possible example of such a situation was brought out with regard to the use of the northern anchovy by the Hawaiian pole-and-line fishermen. It was pointed out that in the recent trials of northern anchovy brought in from California, the Hawaiian fishermen chummed northern anchovy to initially attract the skipjack tuna schools to the boat. Once the skipjack tuna were attracted to the stern, the chummer switched to nehu in fishing the school. However, a comment was made that in not using the northern anchovy while fishing, the Hawaiian fishermen merely assumed that the northern anchovy was not as good as nehu. It was concluded that there may be some relevancy to this comment because it was also pointed out that perhaps the lack of a sufficient amount of northern anchovy was the reason why the Hawaiian fishermen used it so sparingly.

Another item brought up in the desirable characters of a baitfish was that the maximum size of the fish need not exceed 8 cm. It was noted in WP/Gen/3 that based on what is known about the visual

acuity of skipjack tuna and the clarity of the water in extremely clear water, a baitfish 8 cm long could be detected at 50 m, which under most circumstances in tropical waters is well within the usual distance a fish school is away from the boat when chumming is initiated. The question of whether the attractiveness of bait could be evaluated by determining what skipjack tuna eats was raised. However, it was pointed out that tunas are opportunistic feeders and ate almost anything they encountered.

On the item of the fishermen's acceptability of bait, it was brought out that fishermen acceptance has a lot to do with the species of bait actively being used, and that fishermen's acceptance was a real problem.

During the course of the discussion it became apparent that the seven categories listed could be subdivided into two areas, one as it relates to the fishermen's requirements and the other as it relates to the tuna's requirements. Consequently, the categories were rearranged to reflect this in the following manner:

Fishermen related

1. Survival
2. Fishermen acceptance
3. Availability
 - a. Natural stocks
 - b. Cultured stocks

Tuna related

1. Behavior when chummed at sea
 - a. Attract and hold
 - b. Movement
2. Size
3. Color
4. Body form

It was decided that it would be useful to list some of the more important baitfishes now being used in various areas to see how they measured up to the seven categories. Before proceeding with this there was further discussion on the suitability of some of the categories for this exercise. It was then decided that some of the categories were not relevant and were not used in the listing. It was also decided the comparison of the bait species would be based on how they compare among themselves with regard to the selected categories. The listing is shown below.

Category	Species					
	Dussumieridae	Stolephorus sp.	Anchovy	Caesioididae	Apogonidae	Atherinidae Clupeidae
Survival	Weak	Weak	Medium	Strong	Strong	Strong Medium
Abundance						
Eastern Pacific	?	Low	High	None	High	High
Central Pacific	Low	Moderate	Low	None	Low	Low
Western Pacific	High	High	High	Low	Low	High
Behavior	Good	Good	Good	Good	Poor	Fair
Size ¹	5 cm	4-6 cm	8-14 cm	4-8 cm	4-5 cm	8-14 cm
Body form	Elongate	Elongate	Elongate	Elongate	Deep-bodied	Elongate
Color	Shiny	Shiny	Shiny	Dull	Shiny	Shiny
Color pattern	Silvery	Silvery	Silvery	Nonsilvery	Nonsilvery	Silvery

¹Size used as bait.

In general, it was apparent that there are many variables involved in the determination of what is a good baitfish and that many of the variables are difficult to define.

REPORT OF FINAL GENERAL SESSION

Chairman : Richard S. Shomura (in place of Michio Takata)
Rapporteur: Robert T. B. Iversen

A. Discussion.

Each of the chairmen of the working groups briefly summarized the major findings of each session, as given in the rapporteur's reports. It was pointed out that identification of the different agencies and organizations to carry out the various recommendations would serve a most useful purpose for the orderly progress of future work. It was again emphasized that there is no one single solution that will solve the baitfish problems of the various areas, and that the economics of the various methods proposed for alleviating baitfish shortages be kept firmly in the forefront on a continuing basis as the technical developments proceed. The need for a critical experimental design for field trials was again noted. It was suggested that a systems analysis review of all facets of the baitfish problem, drawing on the background information and recommendations made at this workshop, should be carried out as soon as possible by the National Marine Fisheries Service.

B. Priorities for action/alternatives

The participants then held a general discussion on the order in which further studies should be held, covering both short-term and long-term activities. These are given in the table below. In general, the first priority for Hawaii is the anchovy transport

system test, for American Samoa the culturing and sea trials of mollies, the initiation of studies on Apogon by the Trust Territory of the Pacific Islands, and for the other areas, the development of cultured baitfish and development of natural stocks.

C. } Acknowledgments

The participants voiced their thanks to Chairman Richard S. Shomura and the staff of the Honolulu Laboratory, Southwest Fisheries Center, National Marine Fisheries Service, for the outstanding support and hospitality accorded them during the Tuna Baitfish Workshop.

Action Priorities/Alternatives

	1	2	3
Hawaii	Anchovy transport (Sea Grant, NMFS)	Improve bait handling and utilization (nehu)	Shiners and shad
American Samoa	Mollies (Govt. of Am. Samoa)	Economic evaluation of bait transport	---
Trust Territory	<u>Apogon</u>	---	---
Other areas	Develop use of natural stocks (availability and accessibility)	Culture suitable species	---

REPORT OF NATURAL STOCKS SESSION

Chairman : R. Kearney
Rapporteur: J. Wetherall

A. Objectives

1. To evaluate the principal natural baitfish resources of the Pacific with respect to their capacity either to support local skipjack tuna fisheries or as sources of bait for distant-water transport ventures.
2. To recommend specific actions for improving the understanding, development and management of the natural bait fisheries.

B. Resource Evaluation

The group agreed that the main baitfish resources of the Pacific fell naturally into three distinct classes.

1. In the first category are the large stocks of Engraulis occurring in the eastern Pacific and off Japan, Korea, Taiwan, the Philippines and Australia. These stocks, with some questions on the Philippines, are judged to be adequate to support any local skipjack tuna fishery as well as providing low cost sources of bait for transport schemes. The Japanese stocks of E. japonica currently support Japan's local skipjack tuna fisheries as well as her distant Southern Seas operations.
2. In the second group are smaller stocks of other baitfishes, principally Stolephorus, which currently support stable or growing local skipjack tuna fisheries. These are in Hawaii, Palau, Papua New Guinea, and the Solomons.

In Hawaii the principal baitfish is the nehu, S. purpureus. The abundance of nehu is thought to be independent of baiting effort (at current levels). Demand for the bait peaks in the summer. Availability of the nehu is quite variable with perhaps tenfold variation in average catch rates from week to week. Shortages may occur both during the off season and in the summer period of peak skipjack tuna abundance when baiting effort is also highest. Most bait is taken in day fisheries, so the opportunity cost of the bait is very high, especially during the summer. It is unlikely that any sizeable expansion of the skipjack tuna fishery will be possible without the introduction of substitute baits.

In Palau, S. heterolobus supports a modest skipjack tuna fishery, and the current harvest of bait is thought to be approaching the maximum sustainable yield of the stock. Further expansion of the skipjack tuna fishery is possible primarily through improved bait handling and conservation of bait on the vessels.

In Papua New Guinea, Stolephorus resources are ample enough to support an expansion of the skipjack tuna fishery with current fishing practices. In addition, with improved handling and carrying techniques a significant expansion of the skipjack tuna operations could be realized without an increase in bait catch. As in the Palauan and Hawaiian bait fisheries, catch

rates are quite variable, but no long-term fluctuations in abundance have been noted.

In the British Solomons, stocks of Stolephorus support a harvest of 6,000 metric tons of skipjack tuna. Prospects for expansion are unknown.

2. The third category includes the baitfish stocks of all other areas, which are either known to be poor (such as American Samoa) or where information was too scanty to permit an accurate assessment of potentials. Included here also are Fiji, where a skipjack tuna fishery development program is beginning, based on local bait resources, and New Caledonia, where the activities of Japanese fishing interests suggest the possibility of adequate local bait stocks.

C. Recommendations

The group recommended that steps be taken to

1. Develop better bait handling and holding techniques to permit the fullest utilization of catches from natural baitfish stocks.
2. Clarify the taxonomic status and nomenclature of the Stolephorids and establish a reference collection of specimens.
3. Encourage the exchange of "loose" information on natural baitfish research, such as summaries of unpublished data and trip reports.
4. Adopt the recommendations of the South Pacific Commission's Expert Committee on Tropical Skipjack regarding the collection of bait catch statistics from joint venture skipjack tuna fisheries throughout the Pacific. The group suggests that

the data list prepared by the Committee be extended to include a measure of nominal baiting effort, such as the number of net lifts or sets corresponding to the reported bait catch.

REPORT OF SESSION ON CULTURED BAITFISH SPECIES

Chairman : Richard S. Shomura
Rapporteur: Robert T. B. Iversen

A. References

Ref/3, Ref/6, Ref/7, Ref/10, Ref/11, WP/Gen/7, WP/Gen/13, WP/Gen/14(new), WP/CB/1, WP/CB/2, WP/CB/4, WP/CB/5, WP/CB/6, WP/CB/7, WP/CB/8, WP/BT/1.

B. Discussion

It was emphasized the results of this session should be recommendations and priorities for subsequent action in the further development of cultured baitfishes. Such guidelines, it was pointed out, are particularly needed by funding agencies such as Sea Grant, which has programs geared to applied research with a short-term payoff. It was recognized that many problems are of a long range nature; thus the overall development of cultured tuna baitfish must be considered on both a short range (i.e. 1-2 years) and long range basis. The fact that there is no single solution to the use of cultured baitfish which will solve the problems of all areas was repeatedly noted. Problems differ markedly from area to area, especially regarding such factors as the availability of land and fresh water. Several members of the group suggested studies on the economics of culture be initiated immediately and carried out on a continuing basis. The discussion of the results of field experiments to date brought out the fact that the design of field experiments needs to be critically reviewed, particularly the sample size necessary to obtain

a clear answer to the question of the effectiveness of the bait at sea. In this regard it was strongly emphasized by Dr. Rothschild that an analysis of the fishing power of the various bait species accompany the examination of the problem of critical design of field trial experiments.

It was also noted that a continuing search for other candidates for baitfish culture be carried out by the various agencies. An inherent dilemma that is generated by the constraints imposed by the finances available may be involved in field testing. On the one hand, field tests should have an adequate sample size, but on the other hand the funds available may make such controlled testing difficult, particularly if the fishing vessel is not under charter.

It was pointed out that short range objectives might be best met by starting with a species that has been previously studied, has shown some promise, and which would not require extensive funding, and which should produce answers within a year or so. In this regard, the choice of species for further immediate testing should probably concentrate on species that most closely resemble the baits traditionally used.

The problem of acceptance of new baitfishes by the fishermen was repeatedly emphasized and the need for extension service activities to complement field and economic studies may be a critical factor.

C. Criteria for culture

Mr. Martin reviewed his report (WP/CB/7) which discusses the general requirements for a species suitable for pond culture. It should: 1) have a high reproductive potential, 2) spawn readily in ponds, 3) obtain food low on the food chain, 4) be readily handled and transported, 5) be euryhaline, 6) lack spines. It was pointed out that even though a species at this time may be less hardy than another (e.g., threadfin shad vs. tilapia), hardiness may develop as experience is gained in culture. Mr. Martin pointed out that when the golden shiner culture industry first started, shiners were extremely delicate to handle, but with the years a much hardier fish has developed, possibly by selection. The possible benefits of polyculture of a bait species with either another non-piscivorous fish or possibly with a crustacean (e.g., Macrobrachium sp.) should be given very serious consideration because 1) the success or failure of the overall operation may depend on additional income generated by the second species and 2) greater production of the baitfish may be possible under a polyculture regime. It was also noted that for the present, the prudent course may be to start culture activities under a monoculture regime, later working into a polyculture regime. Mr. Martin also pointed out that for some species the use of small ponds may produce more baitfishes than larger ponds, and that the results of preliminary pond culture studies are most likely

underestimates of production, since the standing crops of some species in the wild are sometimes much greater than have resulted from pond culture studies (e.g., threadfin shad).

The general discussion on economics brought out the necessity for a general updating of the costs upon which several of the \$/bucket estimates are made, and also for the necessity of refining the estimates in order that better cost comparisons can be made between intensive culture species (e.g., tilapia) and extensive culture species (e.g., golden shiners, threadfin shad).

D. Species review--critical factors

The group then reviewed the principal species that have been cultured or have a promise for culture and which have been tested in the past. These principal factors are summarized in the accompanying table, which considers threadfin shad, tilapia, mollies, golden shiners, and Apogon. The table highlights the fact that for those species about which most is known concerning basic biology, culture potential and preliminary economics, the field tests to date generally have been inclusive, while for Apogon, which is highly accepted bait by Okinawan fishermen in the western Pacific, very little is known about the basic parameters required for culture.

1. Threadfin shad. It was pointed out that threadfin shad may be a suitable candidate for polyculture. It has the advantage of spawning several times during the year and

thermal shock apparently can be used to induce spawning. While the general level of knowledge about pond culture of threadfin shad is rather low, production rates achieved to date can probably be greatly increased. The requirement of large land areas for threadfin shad production was noted as a possible drawback for culture, even on large islands such as in Hawaii. Dr. Kato pointed out, however, that the possibility exists of leasing suitable lands on Maui for \$60 per acre per year. The possibility of using existing stocks in Wahiawa Reservoir, Oahu Island, Hawaii, for further field tests brought out the fact that a possible conflict between recreational and commercial interests may exist, since the general public fishes for catfish, bass, tucunare, and tilapia in the reservoir. However, the fact that this reservoir often has fish kills of large amounts of threadfin shad may indicate that the best use of threadfin shad in the reservoir is to selectively harvest considerable quantities during the year. It was brought out by Mr. Iversen that there are at least 5,000 buckets of threadfin shad in Wahiawa Reservoir in any given year. (Notes: Following the workshop Mr. William Devick, Aquatic Biologist, Hawaii State Division of Fish and Game, stated that on the basis of analysis of CPUE data collected by the NMFS in the reservoir during the years 1969-70 the standing crop of bait-sized threadfin shad was estimated to be 10,000 to 20,000 buckets

with the most likely mode at 14,000-17,000 buckets. Also subsequent to the session, the captains of the MV Anela and MV Neptune stated they would accept additional threadfin shad for use as tuna bait. Dr. Kato reported that the Maui Island skipjack tuna vessels MV Orion and Tradewind were also interested in using threadfin shad.)

2. Tilapia. Several members of the group emphasized the fact that tilapia still holds considerable promise as a cultured tuna baitfish, especially in a number of island areas where tilapia are known to be abundant, the results of field tests notwithstanding. Tilapia have been field tested over the years but under widely varying conditions, thus results have been inconclusive. It was acknowledged, however, that tilapia poses a particular problem for additional field tests because of non-acceptance by the fishermen, in which the fact that it does not resemble traditional baits may play a major factor. Also, the costs of gearing up for additional field tests are high since an intensive (i.e., hatchery) operation would probably be needed and tilapia facilities at present do not exist. The hardness of tilapia and their ease of culture, however, were thought to make tilapia as a good candidate for long-range consideration. In this connection, the very high yield of 13,000 pounds per acre per year of tilapia in a pond operation suggests yields from intensive culture of bait-sized tilapia may be improved.

3. Mollies. It was pointed out that mollies are very easy to culture over a wide variety of environmental conditions (fresh water to 100% sea water) and have excellent potential for intensive culture, the production figure of 18,000 pounds per acre per year being cited. It was pointed out that sharpnosed mollie (Poecilia sphenops) is non-cannibalistic, an important consideration for this group of fishes. The major lack of knowledge for the immediate future for mollies in general concerns their suitability when used at sea. It was noted that the Government of American Samoa has an intensive mollie culture project underway with the goal of producing enough bait for substantial field trials during 1974. The economics of mollie culture, \$2.60/bucket at 30,000 buckets production make this species one of the more attractive choices from a financial standpoint.
4. Golden shiners. It was pointed out that the very high availability of golden shiners on the mainland United States and relative low cost per bucket delivered airshipped to Hawaii (\$4/pound or \$28/bucket) make it a very attractive candidate for further field trials that can be commenced in a relatively short time. The golden shiner industry in the United States covers 27,000 acres of production and the techniques of mass transport are very well known. It was noted that the use of golden shiners requires fresh

water and a closed system aboard skipjack tuna vessels. The difficulties of maintaining close fresh systems over long periods were acknowledged but it was pointed out that for short-term tests (i.e., 1 day) a closed system could be utilized that costs under \$50 to install.

5. Apogon. It was pointed out by Mr. Wilson that Apogon have had a wide acceptance by skipjack tuna fishermen in the western Pacific, especially fishermen from Okinawa, who have developed unique catching methods for these species, which hover around coral heads. These methods are labor intensive, however, but since this species is a mouth breeder and is very hardy, Apogon might be raised under intensive culture techniques. It was emphasized that Apogon is a species that would not face a fisherman's acceptance problem in the western Pacific where it is a commonly used baitfish species. It was noted that Apogon warranted further consideration as a cultured baitfish candidate because of its proven record. It was pointed out that many of the principal factors (see table) concerning Apogon are unknown, especially the matter of the fecundity, so that the immediate problem is the investigation of some of the fundamental life history parameters of this species. It was generally agreed that such studies should be initiated as soon as

possible. The usefulness of Apogon in atoll areas, should intensive culture prove successful, was also emphasized.

E. Recommendations

The session participants recommended the following:

1. Conduct a critical analysis of the design of future field tests in order to provide the sample size needed to provide unambiguous answers on the effectiveness of the different bait species when used at sea.
2. Concurrently with the experimental design, determine the fishing power of the various bait species under consideration, using existing data with particular reference to nehu and other Stolephorus sp. as models.
3. Recognizing the fact that there is no one solution to the baitfish problems of all areas, conduct future culture and field testing studies on a variety of species.
4. Recognizing the need for both short range and long range solutions to the tuna baitfish problem, on the short-term basis conduct additional field tests with species that have previously shown promise, specifically golden shiners and threadfin shad. On a short-term basis, initiate a re-evaluation of the economics upon which the present cost estimates of bait production are based, and evaluate the methods of presenting production data on intensive and extensive culture methods so the results are readily comparable.

On a long-term basis, initiate economic studies which evaluate the comparative costs of culturing the different species as further advances in culture techniques become available.

5. Recognizing the fact that Apogon has an existing acceptance as a tuna baitfish, and because of its mouth breeding reproductive method and general hardiness, initiate studies as soon as possible on such critical parameters such as fecundity, in order to provide definitive answers as to whether this species should be further investigated as a bait fish culture species.
6. Recognizing that not all possible candidates for baitfish culture have been considered at this workshop, conduct a continuing search for other candidates.
7. Recognizing the fact that fisherman's acceptance of any new bait may be a formidable obstacle to overcome, conduct baitfish extension activities concurrently with the testing of species that show promising results.

shipment, the strategy was to load the bait into the tank as close to the freighter's sailing time as possible, in order that the tank could be tied into the ship's water system from the very outset. In this way, it was hoped that the better-quality oceanic water flowing through the system would reduce the initial mortality that seriously plagued us on the first two trials.

Discussions then centered around the importance of "aging" the bait before they are transported. California bait dealers as well as Japanese bait dealers uniformly experience about a 30% "initial" mortality; or mortality of bait attributable to stress of capture. Some bait would die regardless of how carefully they may be netted and handled. Bait dealers find that after this initial mortality, survival can be greatly increased by the process of "aging" the bait. This involves holding the baitfish in receivers over a minimum period of a week during which time weak fish are eliminated and the survivors are generally strong enough to withstand considerable stress of confinement in baitwells, or presumably in our transport tank. Japanese long-range skipjack tuna fishermen are finding that by purchasing strong "aged" bait, they are able to go to distant equatorial waters with relatively low mortality since these fish are better able to withstand abrupt temperature changes that would have deleterious effect on "green" bait.

Because of the importance of aging, the group decided that the strategy for the third trial shipment should be changed. Some means of aging the fish before transport must be found.

Suggestions included:

1. asking bait dealer in Long Beach to age bait for us,
2. add smaller quantities of anchovy into the tank (perhaps about 400 pounds) on each day for about three or four successive days, each day weeding out the dead fish.

In this way, we would end up with a core of stronger "aged" bait in the tank. The Honolulu Laboratory personnel agreed to change our strategy to comply with the group's suggestions.

At this point the Chairman asked the group for a frank appraisal of the Laboratory's bait-transport project, of whether or not we were going about this problem in the right way. The responses were heavily in favor of the project, and of the approaches used. However, it was agreed that at this stage, we should probably not start into modifying a second fuel tank (already available) into a second transport tank. Another trial shipment should provide a better basis on which to decide whether or not this particular tank would be worth developing further. In the meanwhile, however, some design studies should be started to see whether other tank configurations may not be better. It was agreed that tanks designed specifically

to carry fish would certainly meet our needs better, but that cost factors would have to be taken into consideration. One suggestion was that a circular or oval tank, 7-8 foot in diameter and constructed of 1/4" stainless steel may be placed on a 40-foot flatbed trailer and be transported on the Roll on/Roll off freighter. Such a tank may have a water capacity equivalent to the present transport tank. Another suggestion was that, rather than a single large tank, five separate circular tanks could be constructed and placed on a flatbed trailer. These individual tanks could be tied together in a series so that a single pump unit and a manifold system could supply the proper life-support throughout. The advantage in the latter would be that each tank could be lifted off the trailer individually and be placed into a holding tank to allow the fish to swim out, thus reducing bait handling considerably.

Mr. Puffinburger agreed to work with the Honolulu Laboratory personnel in getting cost estimates for constructing such tanks. Design studies will be initiated immediately.

Further discussions centered around the various problem areas that have come into focus since the start of our experiments. One is that the Matson freighters are presently limited to carrying two tanks on each sailing (this limitation is imposed by the ship's water system). Another was in Matson's schedules. Presently two roll on/Roll off ships, the

LURLINE and the MATSONIA are making round trips between Los Angeles and Honolulu. Future plans are for Matson to get into a three-point schedule, with ships touching at Oakland, Los Angeles and Honolulu. When this triangle route is adopted, this may affect our transport scheduling seriously. Another problem was with the availability of "proper sized" baitfish. The Hawaiian fishermen feel that the anchovy returned to Honolulu in the first two trial shipments were too large and they would prefer anchovy about 3-4 inches in overall length. Mr. Everingham and others mentioned that the smaller "pinhead" anchovy are abundant during the summer months. These pinheads are reputed to be weak, but it was stated that after aging, these are actually quite hardy. Such pinhead anchovy would serve the Hawaiian fishermen well.

Concerning the economics of baitfish transport, reference was made to data summarized in WP/BT/4. It was pointed out that the break-even cost per bucket of anchovy, shipped to Hawaii under various combinations of mortalities and ultimate load of survivors (Tables 8-10) was in the general range where this transport-system may be economically feasible if further developed. This would mean the addition of more tanks in the future in a full-scale system, perhaps with two tanks of fish coming across every few days especially during the summer months.

The development of the bait-transport hardware and the various experiments conducted on carrying density, logistics of the system, etc. would be of immediate application to the Hawaiian skipjack tuna fishery, but the resulting findings would be equally applicable to fisheries located elsewhere, such as in American Samoa, Trust Territory, Guam, etc. For example, bait for Guam may possibly be transported from the Philippines.

It was emphasized that the bait-transport system is primarily to augment the available natural stocks of nehu in the Hawaiian fishery. Transported bait may enable fishermen to

1. range farther during Hawaii's off-season because these anchovy are hardier baitfish,
2. may enable new boats to join the Hawaiian skipjack tuna fleet once availability of baitfish is no longer a constraining factor,
3. may enable reduction in crewsize on Hawaiian boats since the number of fishermen may not necessarily be regulated by manpower needed to catch own bait, and
4. would greatly increase flexibility of operations, where fishermen no longer need to rely so heavily on the fluctuating supply of nehu.

Bait-transport by tanks, though important in itself, may not be considered the single alternative to solving Hawaii's problems.

A full-scale system may include in addition, baitboats to

haul anchovy during the eastern Pacific off-season (also off-season here in Hawaii). In any case, other alternatives must always be considered.

In summary, it was pointed out by tuna industry representatives that future purse seining trials in the central and western Pacific will probably involve a compromise between the use of live bait and purse seine. Bait will probably be used to chum and hold the schools while the purse seine is set. Therefore, live bait will continue to be an important part of fishing for surface schools of tuna, regardless of the gear used. It was brought out that it is vitally important to develop a workable bait transport system immediately so that the knowledge gained and expertise acquired from the trial shipments could be used in the future.

Participants attending the sessions on Natural Stocks and on Baitfish Transport, met together to discuss problems involved in bait survival and handling. It was pointed out that proper handling of bait during capture and during transfer from net to baitwell could reduce mortalities significantly. Stick-held dip net to capture bait at night was found to be superior to seines in reducing mortalities during capture. Transferring bait from net to baitwells during daylight hours also reduced mortalities substantially. Stolephorids showed less avoidance when they were being induced from the net into blue-colored buckets. However,

they obviously showed strong avoidance towards red or yellow buckets. One of the most significant results obtained in experiments conducted in Papua New Guinea was that bait mortalities could be reduced substantially by transferring about 0.8 kg (1.75 pounds) of bait at a time in a 4-gallon bucket..

Discussion also brought out that a new vessel, designed for use in Trust Territory waters, incorporates a system of transferring bait without the use of buckets or scoops. The system involves the use of small openings cut into the hull of the vessel below the water lines. Bait caught and held in nets can then be induced to swim into the baitwells by use of lights and currents. A quite similar system is already being used by Mr. Everingham in San Diego.

C. List of participants

P. Callahan	O. Kerns
S. Comitini	D. Mackett
P. Crosby	E. Oswald
R. Everingham	T. Otsu
D. Gates	J. Puffinburger
R. Gooding	N. Tsue
R. Green	R. Uchida



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National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Fisheries Center
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TO ALL PARTICIPANTS IN THE
SIXTEENTH HAWAIIAN INTERNATIONAL BILLFISH TOURNAMENT

Tournament time is here again. The National Marine Fisheries Service is happy to be a participant in the Sixteenth Hawaiian International Billfish Tournament. As in the past we will perform the scientific task and ask your assistance in obtaining the scientific benefits from this outstanding sports fishing event.

This year we plan to continue our shoreside research and ask your permission to collect measurements and samples of internal organs from your catch. Be assured that we will not touch any fish without your permission, nor will we touch it until it has been officially weighed and recorded. If you wish to mount any portion of your prize, all care will be taken not to mar it.

Because of some new findings in the problem of mercury content, which will be presented at the workshop, the shoreside sampling will include collecting various parts of the fish for mercury analysis. The sampling crew will be led by Heeny Yuen. If you have questions on billfish biology or the work that the National Marine Fisheries Service is doing he will do his best to answer them.

Attached is a report on the data collected at the Hawaiian International Billfish Tournament for the years 1962-72. This report was written by John Naughton and published in the Marine Fisheries Review, a monthly magazine published by the National Marine Fisheries Service. His Figure 1 which shows the fish contact rate in the tournament area over the years does not include 1973. We are including that as a separate attachment. Other attachments are graphs from which you can estimate a fish's weight simply by measuring its total length (tip of bill to fork of tail). These graphs, derived from hundreds of measurements, depict the average condition. The fish that you catch will vary more or less from the graph. This is especially true for very large fish.

Thank you very much for your cooperation. Good fishing in the Tournament.

A handwritten signature in dark ink, appearing to read "Richard S. Shomura".

Richard S. Shomura
Director, Honolulu Laboratory

Attachments

JUN 24 1974

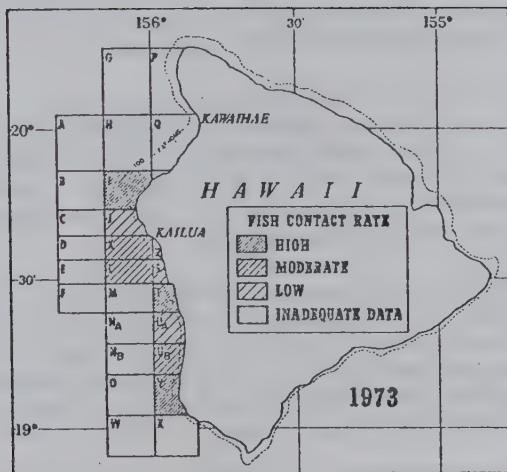
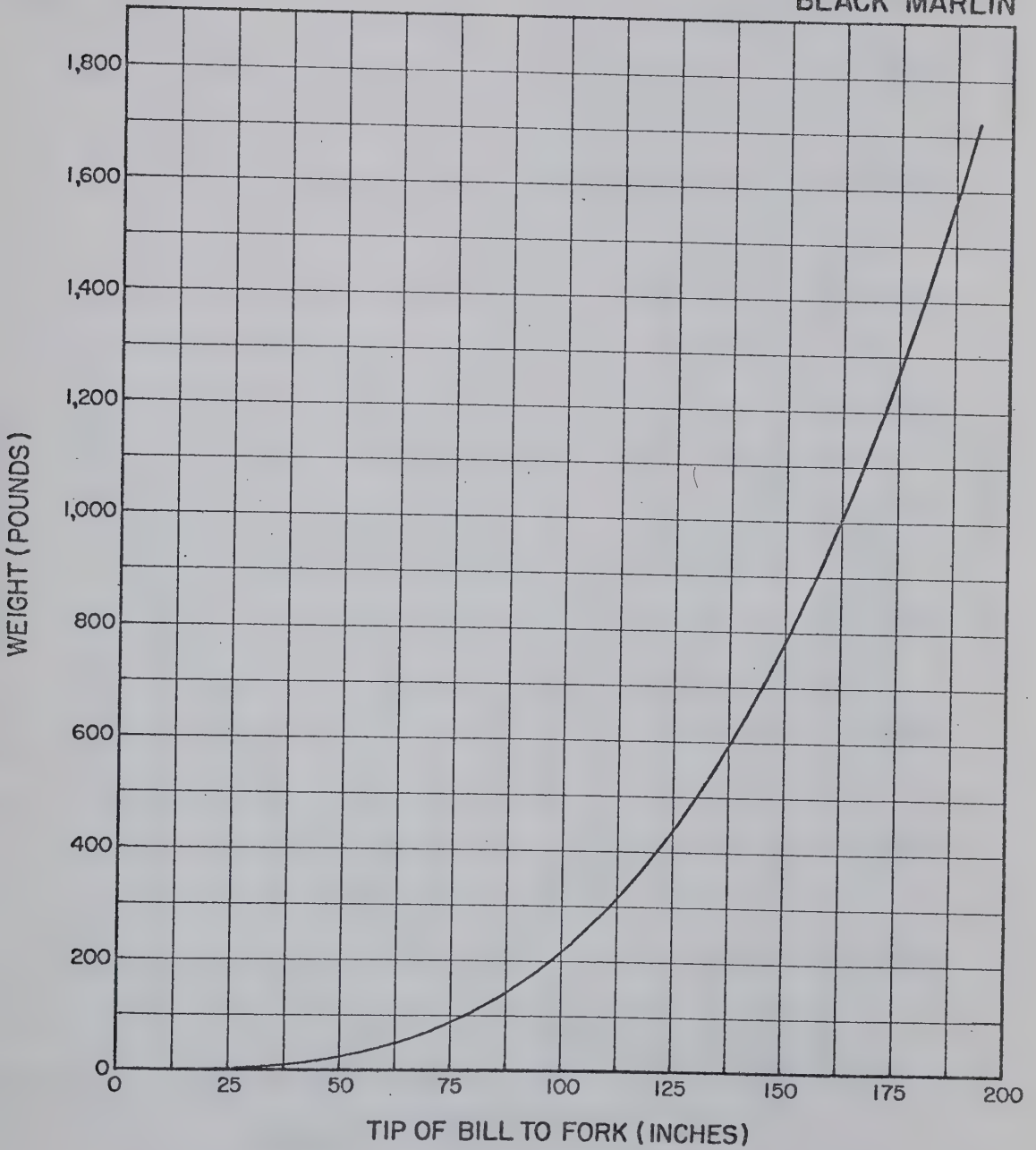
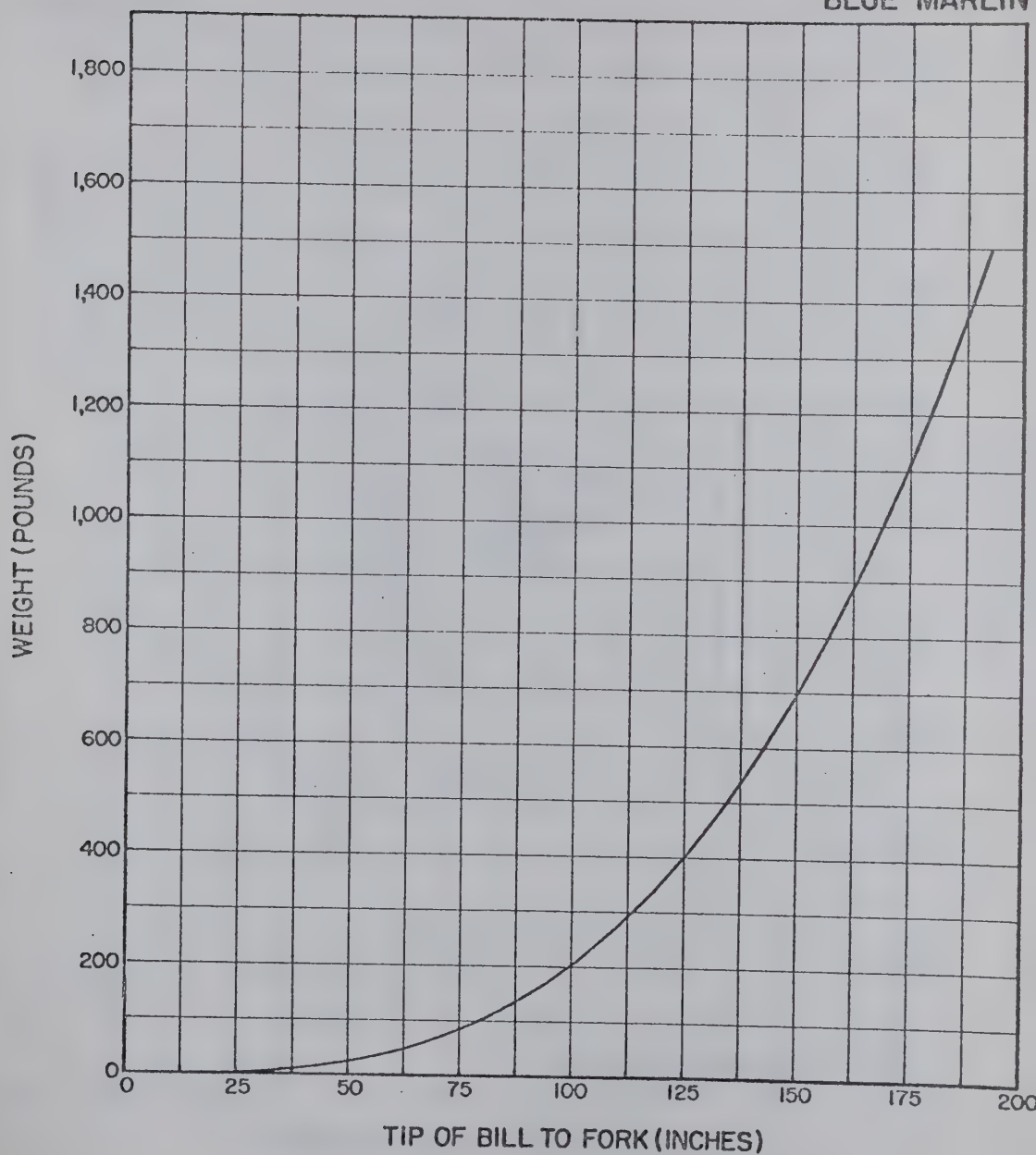


Figure 1.--Fish contact rates in the various fishing areas.

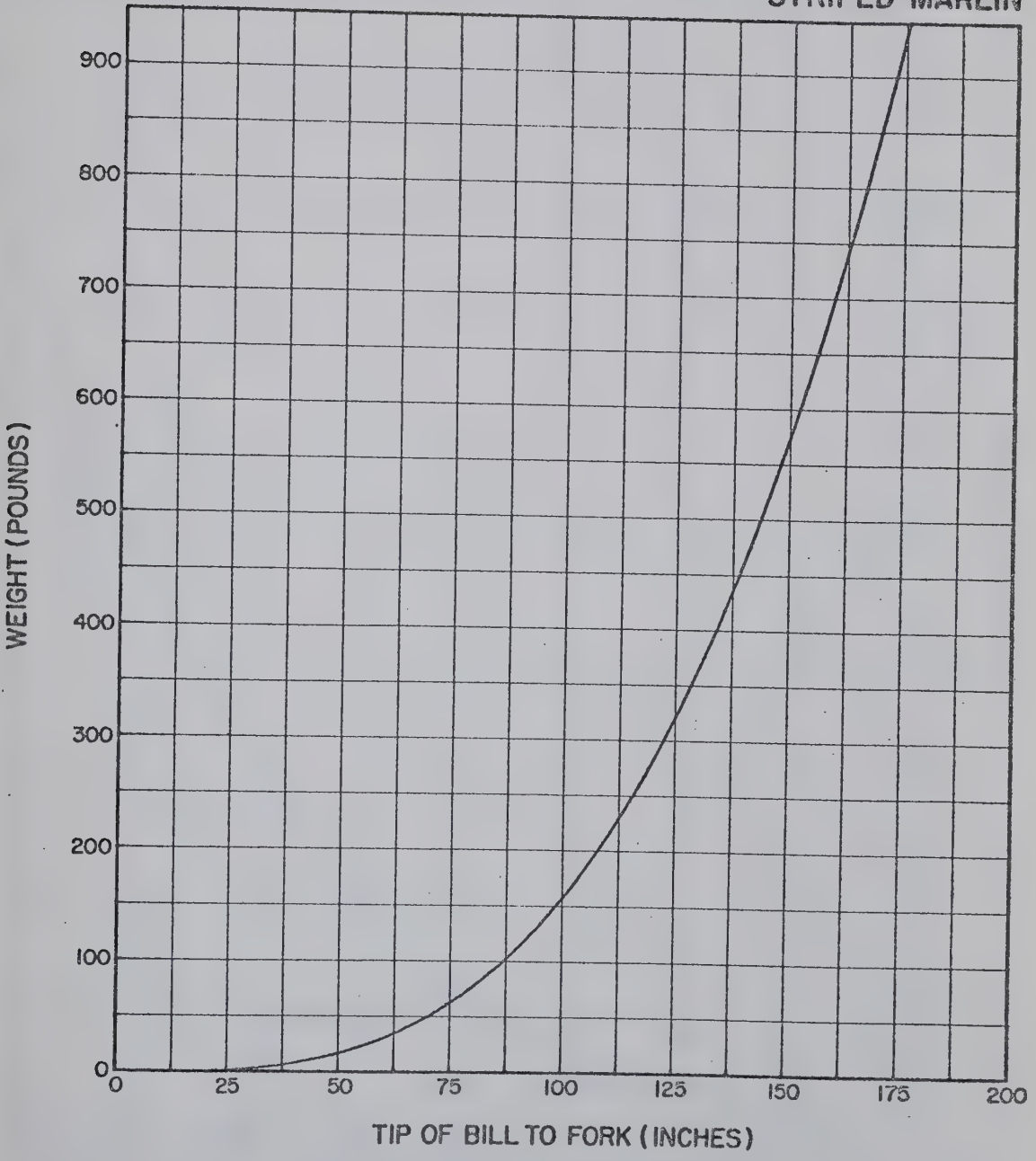
BLACK MARLIN



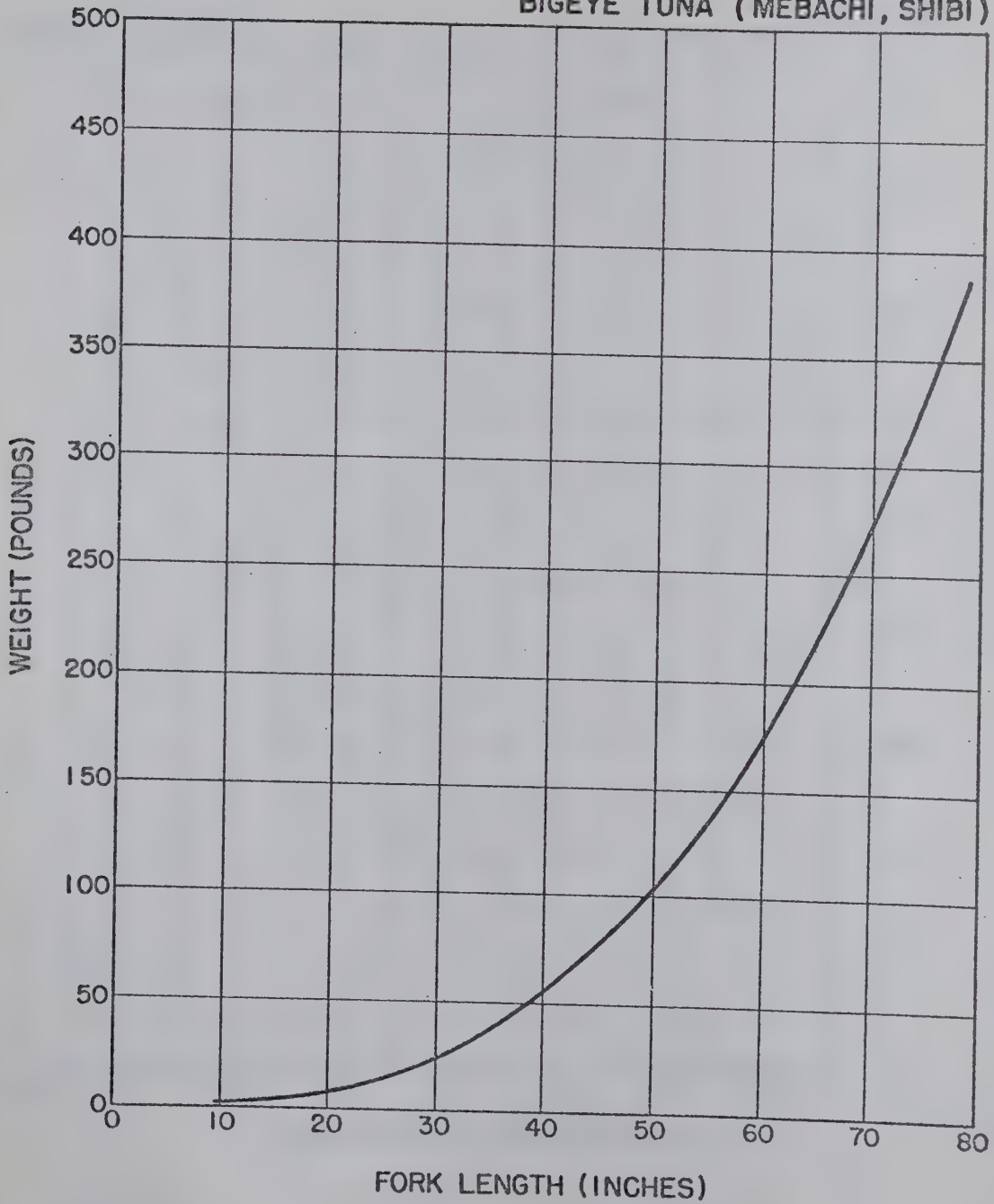
BLUE MARLIN

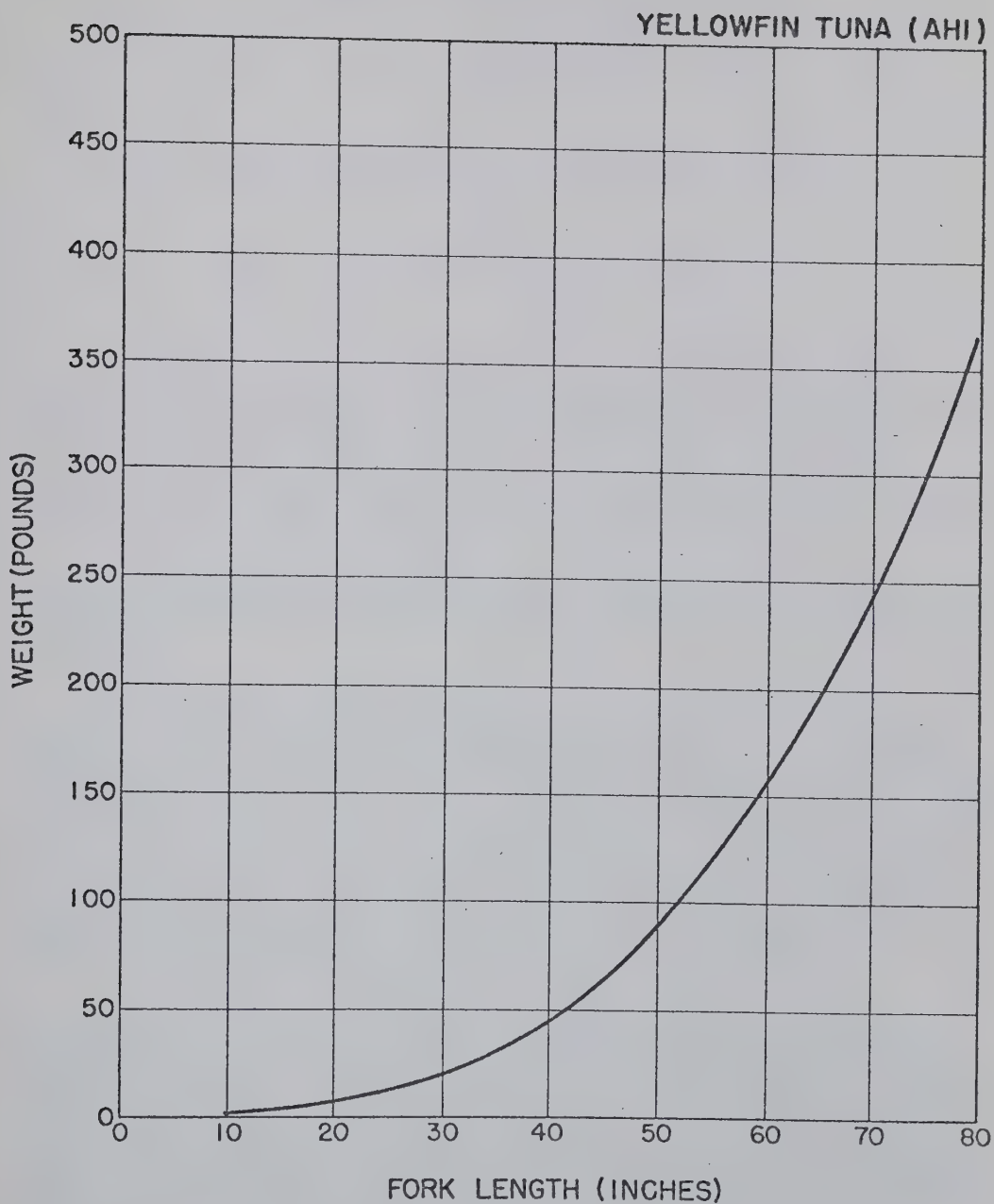


STRIPED MARLIN



BIGEYE TUNA (MEBACHI, SHIBI)





LENGTH-WEIGHT RELATIONSHIP FOR YELLOWFIN TUNA (AHI).



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A Comment on the Study of
Skipjack Tuna Subpopulations by Morphometric Analysis

By

Jerry A. Wetherall¹ and Robert A. Skillman¹

At its April 1974 meeting in Tahiti, the South Pacific Commission's Expert Committee on Tropical Skipjack recommended that a regional study of skipjack tuna morphometrics be undertaken with the purpose of identifying and delineating subpopulations supporting the skipjack tuna fisheries in Tahiti, Papua New Guinea and Hawaii. The Honolulu Laboratory agreed to evaluate this proposal and to provide analytical services and guidelines for data collection in the event that the proposal was implemented.

We have reviewed the proposal in the light of the Committee's objectives and results of previous studies of skipjack tuna subpopulations in the Pacific. We recommend that the proposal not be adopted, and argue as follows:

The study would not add significantly to our understanding of skipjack tuna population structure. Virtually every study of tuna morphometrics has shown statistically significant differences between populations in different areas. In fact, W. F. Royce concluded that even with samples from closely related stocks, highly significant differences could always be found by increasing the size of the samples, by considering a larger set of characters or by applying more critical statistical tests. Since our natural assumption is that skipjack tuna stocks in the different regions are at least partly independent, a finding of significant differences in morphometrics would not be particularly revealing.

Further, a study of morphometrics cannot shed light on the key questions of stock or subpopulation interrelations, such as the presence of intermingling, the degree of intermingling, or the dynamics of interpopulation migration. These problems must be attacked directly, through such means as mark-and-recapture experiments. We note here that the most significant evidence concerning the interrelations between skipjack tuna in the Hawaiian and eastern Pacific fisheries has been the recapture in Hawaii of fish tagged in the eastern Pacific. The several studies of morphometrics contributed nothing to the elucidation of this issue.

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 NATIONAL MARINE FISHERIES SERVICE

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August 2, 1974

Reply to Attn. of:

F14 Dr. Brian J. Rothschild, Director, Southwest Fisheries Center, La Jolla

F142 Richard S. Shomura, Director, Honolulu Laboratory *AKA*

Trip Report - 7th Technical Fisheries Meeting, South Pacific Commission
 (Nuku'alofa, Tonga, 15-19 July 1974)

The 7th Technical Meeting on Fisheries was held at Nuku'alofa, Kingdom of Tonga, on 15-19 July 1974. The meeting was chaired by Mr. Tomasini Simiki, Director of Agriculture, Tonga. The following summarizes the highlights of the meeting:

1. Skipjack Tuna

Nearly all of the island countries and territories of the South Pacific consider the development of skipjack tuna fisheries as a high priority item for economic development and to meet the protein needs of the island communities. The current status of the skipjack tuna fisheries in the several areas are:

(a) American Samoa.--Surveys indicate occurrence of skipjack tuna in commercial abundance in American Samoa. Natural source of baitfish species is inadequate for any development of a pole-and-line fishery for skipjack tuna; therefore, the Office of Marine Resources is presently conducting culture trials of several species of "mollie."

(b) Fiji.--The UNDP-FAO project to survey the skipjack tuna and baitfish resources of Fiji was completed earlier this year. The results indicate that skipjack tuna occur in commercial abundance in the waters around Fiji. Unlike many areas of the South Pacific, Fiji appears to have an adequate supply of naturally occurring baitfish species for the development of a small pole-and-line fishery. Although the initial plans of the Government of Fiji involved undertaking a joint venture with a foreign fisheries company, we were informed at the meeting that the Government of Fiji has decided to undertake the development of the skipjack fishery by itself. This means involvement over the entire spectrum of the fishery including boatbuilding, training of fishermen, and the development of the production, canning and marketing aspects of the industry. From informal discussion, it appears that Fiji has looked on the one hand at the relatively easy time that the joint ventures in Papua New Guinea and the British Solomons encountered in developing a skipjack tuna fishery and, on the other hand, noted that the island governments have not received what is considered due share of economic benefits from the joint venture agreements. The development or lack of development of a

skipjack tuna fishery in Fiji will be observed very carefully by other island countries and territories over the next several years since many of these areas are still trying to seek a solution to their own development of skipjack tuna fisheries. Fiji plans to build up to a fleet of 10 pole-and-line boats within 5 years. The reason for limiting the number of boats is to provide a chance to monitor the fishing effects that the fleet will impose on the baitfish resource.

(c) French Polynesia.--The territory of French Polynesia is also looking toward the development of skipjack tuna fisheries. Currently they have an active small-boat (bonitier) fishery which lands approximately 500 tons per annum. Current plans are to convert the present bonitier fleet into a pole-and-line fleet made up of larger vessels. A study is being initiated to determine the extent of natural baitfish resources and the possibility of culturing baitfish in ponds. In connection with the latter, the Honolulu Laboratory has sent three shipments of threadfin shad to Tahiti by commercial airline. Only the third shipment was successful and six shad survived the Honolulu-Tahiti trip in June 1974.

(d) Gilbert and Ellice Islands Colony.--The colony looks towards the early development of skipjack tuna in order to counteract the anticipated loss in revenue from mining of phosphates. The phosphate mining is expected to cease in 1978. Although inquiries for possible joint venture agreements have been submitted to foreign elements, the colony has received no response to date. The results of a study conducted by the Japanese which indicated an inadequate supply of baitfish may have a bearing to the lack of interest. The UNDP recently initiated a study to culture baitfish in the Tarawa Lagoon. The initial work will be with the rearing of milkfish (Chanos chanos) in ponds. The young of this species will be taken from the wild and grown in captivity. In addition, it was noted that surveys of the tuna resources around Christmas Island are being carried out.

(e) New Caledonia.--Development of the skipjack tuna fishery is still in the planning stage. One of the first projects planned is to conduct a survey of the baitfish resources around New Caledonia.

(f) Papua New Guinea.--Papua New Guinea represents the prime evidence that new skipjack tuna fisheries can be developed in the Pacific. The fishery, which was initiated in 1970 by joint venture agreements with foreign companies (Japanese and United States) caught approximately 28.3 thousand metric tons in 1973. To date, fishing in 1974 has been good; at the current rate, the 1974 catch is expected to exceed the 1973 high. It is estimated that the 1974 catch will exceed 35.0 thousand metric tons. The present fleet numbers 55 Okinawan-type pole-and-line vessels.

(g) Tonga.--The Kingdom of Tonga has submitted an application to the United Nations Development Program for support to investigate the skipjack tuna and deepwater bottom fishery resources of the area. The fisheries people in Tonga are currently conducting a baitfish survey.

(h) Trust Territory of the Pacific Islands.--The Palau skipjack tuna fishery is having a very good year. In April the catch exceeded 1,000 tons. The fleet currently consists of three Micronesian and six Okinawan boats. Interestingly, it was reported that the Okinawan boats were being crewed by Korean fishermen.

(i) Western Samoa.--An FAO Master-Fisherman (Mr. Walter H. Paulo, former skipper of the Townsend Cromwell) reported for duty in Western Samoa in January 1974. He is currently conducting a tuna baitfish study and hopes to carry out pole-and-line fishing for skipjack tuna aboard a small FAO-built fishing craft.

One of the principal topics discussed at the meeting was a proposed SPC-sponsored major skipjack tuna tagging program. The proposal was recommended by the Expert Committee on Tropical Skipjack organized by the South Pacific Commission. It is hoped that a suitable tagging vessel will be obtained from a donor country. The plans are to carry out extensive skipjack tuna tagging over a 2-3 year period throughout the South Pacific Commission area. It is expected that the results will provide information for stock identification, migration paths of the skipjack tuna and a possible assessment of the size of the skipjack tuna resource in the western and South Pacific. Additionally, the vessel is expected to carry out a great deal of baitfish research and general skipjack tuna survey work in the South Pacific Commission area.

At the request of the Expert Committee on Tropical Skipjack, the Honolulu Laboratory developed a daily tuna catch record form and a form to collect size and sex data of skipjack tuna. There was general agreement that the assessment of the skipjack tuna resources of the central and western Pacific can only be evaluated with data collected under a uniform format.

I provided participants of the meeting with a brief summary of the baitfish workshop held in Honolulu in early June. Participants were very interested in the workshop since many of the areas of concern to the South Pacific Commission are faced with a baitfish supply problem.

2. Dory Project

Several years ago the "Oregon dory" developed by Barry Fisher of Oregon State University was considered the solution for many of the vessel problems faced by the island governments and territories. Presently there are mixed feelings on the suitability of the dory in some areas. Presently dory fleets are operating in American Samoa and Ponape. In American Samoa the major problem has been mechanical failure with the inboard-outboard engines. Present plans are to convert to a diesel engine operation. In Ponape the dories are outfitted with a jet-drive engine. The initial problem encountered with cavitation has been resolved by installing a skeg on the bottom of the vessel.

The South Pacific Commission is currently funding a project to compare a standard dory with an aluminum version. The project will initially be carried out in New Hebrides. It is hoped that the results of the study will indicate whether aluminum has a superior advantage over the standard plywood hull of the current dory.

One interesting comment made by an observer was that the dory cannot be viewed as the salvation of all situations. As an example, in American Samoa, where deepwater facilities are available, a shallow draft should not have been considered necessary. In the observer's opinion, a V-draft would provide for better stability and better riding characteristics. On the other hand, Ponape, which has very limited deepwater facilities, appears to be very satisfied with the shallow-draft Oregon dory.

3. Outer Reef Artisanal Fishing Project

There was considerable discussion on the outer reef resources, primarily because most of the island countries and territories are looking to the outer reef resources as a means to meet their domestic protein needs. Presently there are a number of plans for the outer reef project, including separate plans prepared by the South Pacific Commission, UNDP-FAO, and ICLARM (International Center for Living Aquatic Resources Management). The latter is an ambitious program proposed by the Rockefeller Foundation.

One of the major problems with the utilization of outer reef resources is that of ciguatera. In areas where fishing of the deeper water species is already being carried out, e.g., American Samoa, a considerable part of the catch is being discarded because of potential ciguatera problems. It was noted at the meeting that Dr. H. Banner of the University of Hawaii is currently working on the ciguatera problem. One of the priority needs of the South Pacific Islands area is a method of rapidly determining the level of ciguatera toxin in individual fishes.

4. Turtles

It appears that this is the Year of the Turtles. On the basis of several presentations, it appears that nearly all of the participating countries and island territories are working on sea turtles. Turtle projects are currently being carried out in the Trust Territory, Fiji, Tonga, Cook Islands, Western Samoa, and Papua New Guinea. The meeting avoided making a recommendation on turtles which could be construed by governments to initiate or expand projects on farming or ranching of green turtles.

5. Aquaculture

Aquaculture projects are still being pursued in many of the island countries and territories. It is encouraging to note that, during the discussion on aquaculture, there was continued reference to the need

to evaluate the aquaculture activities on an economic basis. As an example, CNEOX (Centre National pour l'Exploitation des Océans) believes that a Malaysian prawn culture operation in Tahiti is economically viable; however, this is probably not true for most of the smaller island communities where the demand for high-priced prawns is limited and an export industry is not feasible.

6. Others

(a) UNDP Regional Office departure from Western Samoa.--In early June the Government of Western Samoa informed UNDP to vacate their regional office from Western Samoa. From available information it appears that the request from the Prime Minister of Western Samoa that the UNDP Regional Officer, Mr. Hussey, be retained for an additional period beyond his scheduled retirement was rejected by UNDP. Dr. Ray Fort, Acting Regional Officer, and Erling Oswald, Regional Fisheries Coordinator, and their families departed from Apia, Western Samoa during the week of 15 July. The UNDP Regional Office will be temporarily headquartered in Manila, Philippines.

(b) International Center for Living Aquatic Resources Management (ICLARM).--The Rockefeller Foundation recently initiated a "Proposal for the Creation of an International Center for Living Aquatic Resources Management." My understanding is that the Rockefeller Foundation will provide the funds necessary to get his center started. Subsequently the program will be carried on by obtaining grants and funds from other sources. In a nutshell, the proposal appears to undertake activities similar to that conducted by FAO; e.g., fisheries development, aquaculture, research and development, food technology, socio-economic considerations, etc. If the program is funded it could mean additional financial and manpower input into the island countries and territories belonging to the South Pacific Commission.

(c) Statistics.--Arrangements were made to obtain longline catch statistics from fleets based in Fiji and New Hebrides. These data will assist in evaluating the South Pacific albacore resource. Obtaining these data could not have been made as easily without the personal contact opportunities that meetings such as the 7th Technical Fisheries Meeting provide.

(d) General comments.

1. There appears to be a tendency for many of the island governments and territories to undertake too many little projects without proper consideration given to national priorities and without adequate manpower and funds. This lack of critical mass is probably the singlemost shortcoming preventing success of many of the projects. In many areas, there are knowledgeable individuals; however, the multitude of problems simply overwhelms the understaffed personnel.

2. In many instances, it appears that programs are undertaken without complete thought given of the utility and economic benefit. The tendency is to pursue "fad" projects. As an example, in a number of areas, projects are still being planned for the culture of Macrobrachium prawns without having a critical review of its potential economic viability.

Attachment: List of participants

cc: F4 Office of International Fisheries

RECENT DEVELOPMENT IN FISHERIES FOR
SKIPJACK TUNA, KATSUWONUS PELAMIS, IN THE CENTRAL AND
WESTERN PACIFIC AND INDIAN OCEANS

By

Richard N. Uchida
Southwest Fisheries Center
National Marine Fisheries Service, NOAA
Honolulu, HI 96812

This is a draft manuscript presented to the Indian Ocean
Fishery Commission/Indo-Pacific Fisheries Council (IOFC/IPFC) Ad
Hoc Working Party of Scientists on Stock Assessment of Tuna, Nantes,
France, 16-18 September 1974.

It will not be published in the present form and should not be
cited in the literature.

Report of 16th Hawaiian International Billfish Tournament

Kailua-Kona, Hawaii

July 13-20, 1974

Prepared September 12, 1974

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TO ALL BILLFISHERS:

The National Marine Fisheries Service, NOAA, has contributed its scientific skills to the Hawaiian International Billfish Tournament (HIBT) and issued reports on its findings for 13 consecutive years. Here again is our traditional report (if you will permit it to be considered traditional after 13 years).

This is the first year that I participated in the HIBT from beginning to end. The spirit of cooperation and community involvement throughout the tournament was truly enjoyable to experience. Bernard Ito, Ray Sumida, Cynthia Unninayar, and I of the National Marine Fisheries Service express our heartfelt thanks to all the anglers, the tournament officials, and the community volunteers for their assistance and the wonderful experience.

The Sixteenth Annual Hawaiian International Billfish Tournament was an unqualified success from the very impressive opening ceremonies through the final awards banquet. It was highlighted by several records. The catch of 110 qualifying fish is the highest ever for any HIBT event. Haku Baldwin's ahi (yellowfin tuna) of 222 pounds on 80-pound test line set a new world's record for women. Neil Nishikawa's feat of landing a Pacific blue marlin of 762 pounds on 50-pound test line also broke a world's record. Congratulations!

THE CATCH

Making up the record catch of 110 fish were 66 Pacific blue marlin, 35 ahi, 6 shortbill spearfish, 2 black marlin, and 1 striped marlin. The first shortbill spearfish appeared in the tournament 3 years ago. The six caught this year are the most ever caught at the HIBT. The black marlin are also noteworthy. Their appearance in the tournament this year terminates an absence of 5 years.

Sixty-four teams of anglers participated in this year's tournament. Their catch of 110 fish calculates out to 2.9 boat-days per fish. If this figure is adjusted for the shortening of the fishing day from 9 hours to 8 hours, the result is 2.5 boat-days per fish. This rate is 20% better than the previous best of 3.1 boat-days per fish (Table 1).

Sex determinations were made on 60 of the Pacific blue marlin. There were 46 males and 14 females, for a male:female ratio of 3.3:1. Sex ratios of Pacific blue marlin in past tournaments (Table 2) have ranged from 1.2 to 8.0:1, with most of them falling between 2:1 and 3:1.

The weight ranged from 127 pounds to 247 pounds for the males and from 86 pounds to 762 pounds for the females. The 86-pound female is a record breaker of dubious distinction. She is the smallest identified female Pacific blue marlin in HIBT records.

AREAS OF STRIKES AND CATCHES

The most popular fishing area was area I, with 425 boat-hours of fishing for the tournament period. Other areas of heavy fishing pressure in order of popularity were: T, J, U_A, L, K, V, and U_B. Area J provided the most billfishes, with 14 Pacific blue marlin and 1 shortbill spearfish (Table 3). Area T followed with 12 Pacific blue marlin and 1 shortbill spearfish. Area I was third with nine Pacific blue marlin and two black marlin. It is interesting to note that the five leading areas for Pacific blue marlin are areas adjacent to the coast. In fact, 53 of the 66 Pacific blue marlin landed were caught in areas adjacent to the coast.

The largest marlins were caught in areas V and I. The average weight of the Pacific blues caught in areas V and I far exceeded the average weights of the other areas (Table 3). Those caught in area V averaged 419 pounds and those in area I averaged 324 pounds. Compare these averages to the overall average of 224 pounds per Pacific blue marlin. The five blue marlin caught in area V weighed more than all 12 from area T!

Strike rates were calculated for those areas in which there were more than 100 boat-hours of fishing during the tournament (Figure 1). The three top areas were area L with 0.37 strike per boat-hour, area U_B with 0.28, and area J with 0.25.

Reasoning that there must be a correlation between strike rates and catch rates because each catch starts as a strike, I plotted the catch rates against the strike rates (Figure 2). The distribution of points on the plot indicates no correlation at all between strike rates and catch rates. In other words, one is just as likely to catch a fish in an area of low strike rate as in an area of high strike rate. This is an enigma to me, but perhaps if I thought like a fish I would see it clearly.

FISHING TACKLE

Tournament fishermen are evidently making better use of the fish caught as far as points are concerned. Since 1970 the use of 130-pound test line has continually decreased (Figure 3) as more and more fishermen are taking advantage of the bonuses offered for catches on light tackle. In 1970, 67% of the fish were caught on 130-pound test; in 1974 only 10%

were caught on 130-pound test. The percentage of fish caught on 80-pound test has increased steadily from 21% in 1970 to 56% in 1974. The rise in percentage of fish caught on 50-pound test from 13% in 1970 to 34% in 1974 was not as consistent as that for 80-pound test. There was a slight decline in 1973, but a sharp increase was witnessed in 1974.

The graph at the top of Figure 3 shows the percentage of hookups that were landed for the last 5 years. In spite of the tendency towards light tackle the proportion of hookups landed has not decreased. Nor has lighter tackle resulted in smaller fish. The frequency distribution of marlin weights for the three different tackles (Figure 4) shows the same pattern for 80-pound test and 50-pound test lines. In view of this I would venture to guess that in a few years 130-pound tackle will not be used at all in the HIBT.

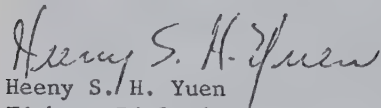
Year after year for 10 years now the strike rates have been superimposed on tide charts as in Figure 5. The relationship between strike rates and tidal phase, if any, remains unclear. In the last 5 years the tournament has been scheduled to coincide with the new moon with dramatic results (Table 1). In 1973 and 1974 whenever a fishing period (equivalent to a radio report period) occurred during low tide, that period had the highest strike rate for the day. In Table 4a I have summarized the tide phase rankings based on strike rates for the last 5 years (1970-1974 inclusive). The strike rates at low water slack tide ranked first in 3 years and second in 2 years. The strike rates during flood tide periods ranked first 1 year and last in 4 years. High water slack tide ranked second in 1 year and last in another. Ebb tide ranked first in 1 year and second in 2 years. From Table 4a low water slack tide appears to be the best time for strikes and flood tide the worst. From 1965 to 1969, when tournaments were not scheduled according to moon phase, a similar summary (Table 4b) shows that strike rates were best during ebb tide. Data in the next few years should result in a decision on whether or not strike rates are related to tide phases.

STOMACH CONTENTS

Fishes of the tuna family were the most common food item found in marlin stomachs this year. They occurred in 45% of the stomachs examined. This occurrence rate of tunas is higher than any recorded for the HIBT in the past. The two dominant species of tunas were skipjack tuna in 20% of the stomachs and frigate mackerel in 18% of the stomachs. The next most common on the list of food items (Table 5) was squid, which was found in 22% of the stomachs. Opelu, a mackerel scad, was also a popular item with an occurrence of 18%. Over the years tunas, squid, and opelu have been the mainstay of the diet of marlins during the tournament. Twenty-two percent of the stomachs were empty.

The stomach contents included a juvenile scorpionfish and a blade of seaweed, items never seen in marlin stomachs in past tournaments. On the other hand, goatfish juveniles were notably missing. The earliness of this year's tournament may have been a factor in their absence as these juveniles usually enter the coastal waters during August and September.

I enjoyed meeting you. Until next year, aloha and good fishing.


Heeny S. H. Yuen
Fishery Biologist

September 12, 1974

Attachments

Table 1.--Numbers of qualifying game fish landed and teams fishing during Hawaiian International Billfish Tournaments, 1962-74.

Year	Blue marlin	Black marlin	Striped marlin	Shortbill spearfish	Sailfish	Yellowfin tuna $\geq$ 100 lb.	Total qualifying fish	Number of teams	Number of boat-days fishing per fish
1962	30	1	--	--	1	19	51	68	6.7
1963	19	2	1	--	--	26	48	72	7.5
1964	31	--	1	--	--	2	34	69	10.1
1965	47	--	--	--	--	9	56	78	6.9
1966	26	3	2	--	--	7	38	72	9.5
1967	63	--	1	--	--	18	82	68	4.2
1968	36	2	4	--	--	4	46	85	9.2
1969	32	1	--	--	--	4	37	75	10.1
1970	91	--	2	--	2	14	109	73	3.3
1971	41	--	3	1	--	47	92	77	3.4
1972	77	--	--	--	--	11	88	59	3.4
1973	76	--	1	3	1	17	98	61	3.1
1974	66	2	1	6	--	37	110	64	2.5

Table 2.--Sex ratios for blue marlin, *Makaira nigricans*, examined from Hawaiian International Billfish Tournaments, 1962-74.

Year	Number of males	Number of females	Ratio males to females
1962	16	7	2.3:1
1963	13	6	2.2:1
1964	14	12	1.2:1
1965	35	8	4.4:1
1966	16	8	2.0:1
1967	51	13	3.9:1
1968	24	10	2.4:1
1969	23	8	2.9:1
1970	63	14	4.5:1
1971	21	9	2.3:1
1972	64	8	8.0:1
1973	47	21	2.2:1
1974	46	14	3.3:1

Table 3.--Number of fish caught in 1974 tournament by species, date, and area.

Date	Area												
	C	I	J	K	L	M	N _A	N _B	S	T	U _A	U _B	V
Pacific blue marlin													
July 15	--	--	2	1	3	--	--	--	1	1	1	2	--
July 16	1	1	2	--	--	--	--	--	1	2	1	2	--
July 17	--	3	6	1	--	--	--	--	--	1	--	--	--
July 18	1	4	3	1	--	--	--	--	2	4	1	--	4
July 19	--	1	1	1	1	1	1	1	2	4	--	--	1
Total	2	9	14	4	4	1	1	1	6	12	3	4	5
Average weight	123.0	323.9	189.6	213.8	195.8	136.0	162.0	182.0	229.3	162.9	170.0	221.8	419.2
Ahi													
July 15	--	1	1	--	--	--	--	--	--	1	--	--	--
July 16	--	3	1	2	--	--	--	--	--	--	--	--	--
July 17	--	3	2	--	--	3	1	--	2	--	1	1	--
July 18	--	2	--	--	1	--	--	--	1	--	2	1	1
July 19	--	--	1	--	--	--	--	1	--	--	--	--	--
Total	--	9	5	2	1	3	1	1	3	1	3	2	1
Average weight	--	159.2	183.2	155.0	111.0	217.3	217.0	120.0	136.7	170.3	200.7	189.0	199.0
Other*													
July 15	--	BM	--	--	SS	SS	--	--	--	--	--	--	--
July 16	--	--	--	--	--	--	--	--	--	--	--	--	--
July 17	--	--	--	--	--	--	--	--	--	--	--	SS	SM
July 18	--	BM	--	--	SS	--	--	--	--	SS	--	--	--
July 19	--	--	SS	--	--	--	--	--	--	--	--	--	--
Total	--	2	1	--	2	1	--	--	--	1	--	1	1
Average weight	--	342.5	26.0	--	23.5	29.0	--	--	--	34.0	--	42.0	35.0

*One fish caught in each cell marked by symbol; BM = black marlin, SM = striped marlin, SS = shortbill spearfish.

Table 4.--Number of years strike rates of tide phases fell in various ranks.

a. 1970-74 inclusive

Tide phase	Strike rate rank		
	1	2	3
Low-water slack	3	2	-
Flood	1	-	4
High-water slack	-	1	1
Ebb	1	2	-

b. 1965-69 inclusive

Tide phase	Strike rate rank			
	1	2	3	4
Low-water slack	-	2.5*	2.5*	-
Flood	-	2.5*	1.5*	1
High-water slack	2	-	1	-
Ebb	3	-	-	1

*Tie in rankings 1 year.

Table 5.--Stomach contents of Pacific blue marlin, Makaira nigricans, from the Hawaiian International Billfish Tournament, 1974

Food items	Date and number of stomachs containing listed food items					Percent occurrence
	7/15	7/16	7/17	7/18	7/19	
<u>Fish</u>						
Tuna, Scombridae						45
Skipjack tuna, <u>Katsuwonus pelamis</u>	2	1	3	3	1	20
Frigate mackerel, <u>Auxis</u> sp.	1	1	2	4	2	18
Unidentified	1	-	2	2	-	10
Jacks, Carangidae						20
Opelu, <u>Decapterus pinnulatus</u>	1	1	1	4	2	18
Akule, <u>Trachurops crumenophthalmus</u>	-	1	-	-	-	2
Mahimahi, <u>Coryphaenidae</u>	-	-	1	1	1	6
Pelagic spiny puffer, <u>Diodontidae</u>	2	2	-	1	1	12
Puffer, <u>Tetraodontidae</u>	-	-	-	1	-	2
Triggerfish, <u>Balistidae</u>	-	-	-	-	2	4
Surgeonfish, <u>Acanthuridae</u>	-	-	1	1	-	4
Lancetfish, <u>Alepisauridae</u>	-	1	1	2	1	10
Snake mackerel, <u>Gempylidae</u>	-	3	-	-	1	8
Butterflyfish, <u>Chaetodontidae</u>	-	-	2	-	-	4
Scorpionfish, <u>Scorpaenidae</u>	-	-	-	1	-	2
Cowfish, <u>Ostraciontidae</u>	-	-	-	1	-	2
Unidentified fish	3	3	4	7	4	43
<u>Invertebrates</u>						
Squid, <u>Decapoda</u>	3	3	1	-	4	22
Empty or everted stomachs	1	3	1	5	1	22
Number of stomachs examined	8	8	11	15	7	
Total: 49						

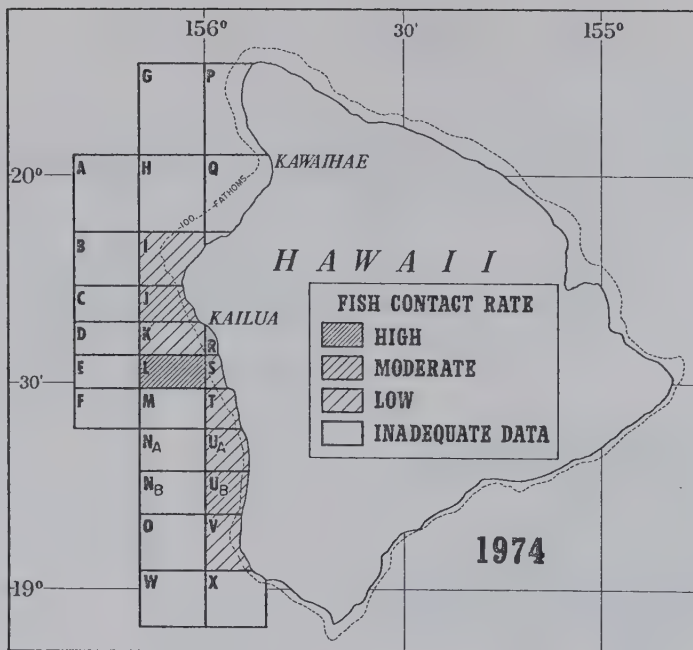


Figure 1.--Fish contact rates in the various fishing areas.

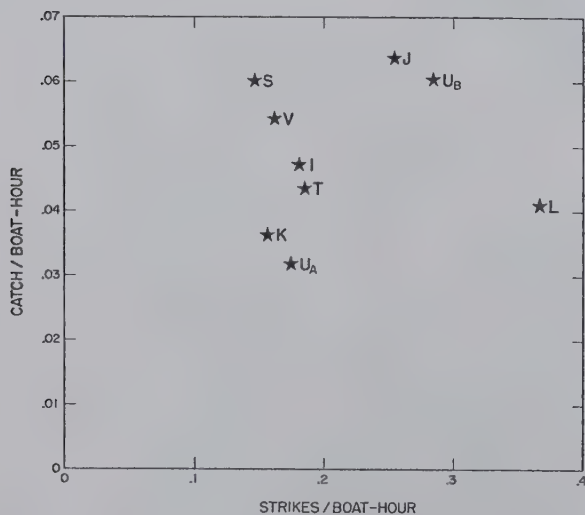


Figure 2.--Plot of catch rates against strike rates. Letters refer to areas.

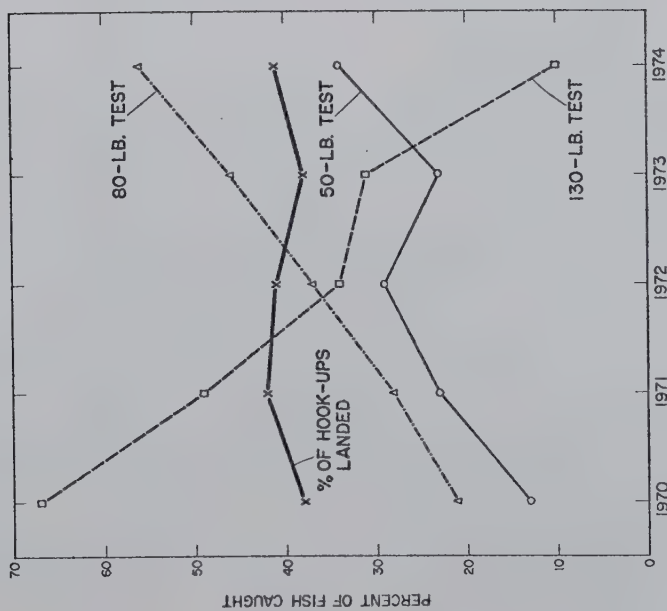


Figure 3.--Proportion of catch landed on various size lines.

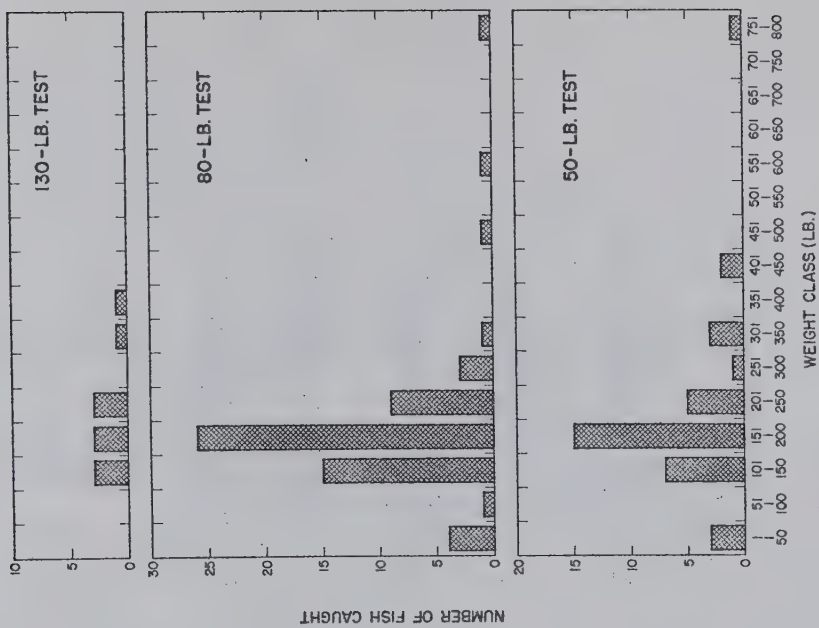


Figure 4.--Frequency distribution of weights of fish caught on various size lines.

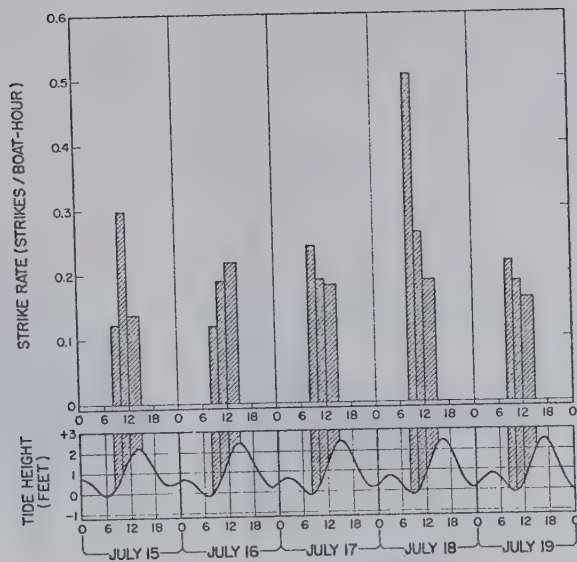


Figure 5.--Strike rates and tide cycle for 1974 HIBT.

September 16, 1974

F142

NMFS Coordinator for PTDF, La Jolla, CA

Richard S. Shomura, Director, Honolulu Laboratory

Marquesas Islands fishing and environment info

Enclosed is a capsule summary of the fishing information covering the Marquesas Islands area published by this Laboratory. The summary was prepared by Howard Yoshida.

The section on oceanographic conditions will be forwarded within the next several days.

Enclosures

RSShomura:cay

attached

Marquesas Islands Fishing Info

In 1956, the Honolulu Laboratory of the National Marine Fisheries Service (NMFS), which was then known as the Pacific Oceanic Fishery Investigations (POFI) of the Fish and Wildlife Service, began an evaluation of the tuna resources of the south central Pacific Ocean centered around the Marquesas Islands. The investigations were structured to obtain answers on the availability of both the surface and deep-swimming tunas, their distribution, and their relationship to the environment.

Initially, the survey cruises were carried out during two periods, the southern hemisphere winter and the southern hemisphere summer, which afforded the greatest contrast in environmental conditions and possibly in the abundance of tuna. The early cruises did indeed show striking differences in the abundance of tuna schools between the two periods. Later cruises were designed to determine the length of the season of greatest abundance of tuna schools around the Marquesas Islands. Also, some effort was expended to expand the survey into the Tuamotu archipelago. The final survey cruises included an expedition made by a chartered West Coast bait boat, the Cape Falcon, out of San Diego, to test the feasibility of fishing commercially in the Marquesas area. The basic data collected on all the cruises were published in the Special Scientific Report series of the Fish and Wildlife Service (Table 1).

An analysis of the results of the first five survey cruises appeared in Wilson and Austin (1957). Wilson and Austin (1959) examined the results of the cruises conducted between October 1957 and June 1958. An analysis of the results of all the survey cruises to the Marquesas Islands, including the cruise made by the Cape Falcon under charter to NMFS, was prepared for presentation to the Government-Industry Tuna Conference held at La Jolla, California, in January 1962 (Austin, T. S. Report on the tuna surveys in the Marquesas Islands. Mimeographed. In the files of NMFS, Honolulu, Hawaii). An assessment of the tuna resources of the Marquesas Islands area was also done by Rothschild and Uchida (1968). In addition, summaries of sightings of bird flocks and tuna schools in the Pacific Ocean, including the Marquesas Islands area have been prepared (Waldron, 1964; Naughton, MS).

These early fishing surveys were conducted by research vessels using the pole-and-line and live bait method of fishing. The paper by Rothschild and Uchida (1968) provides an excellent summary of conditions in the Marquesas Islands area in terms of pole-and-line fishing. Generally, skipjack tuna schools were more numerous than yellowfin tuna schools. The behavior of the skipjack tuna schools were erratic and wild. The schools were fast-traveling. The density of schools was higher during the southern hemisphere summer (January-March). During the periods January 18-25 and February 27-March 5, 174 schools were sighted in 15 days of scouting, which averaged out to a sighting rate of 11.6 schools per vessel per day. This sighting rate was more than twice that experienced in Hawaiian waters. However, the percentage of schools successfully fished appeared to be low compared to that in Hawaii.

The skipjack tuna caught by pole-and-line in the Marquesas ranged from 39 cm (1.1 kilograms or 2.5 pounds) to 83 cm (14.4 kilograms or 31.7 pounds). Most of the fish were between 45 and 55 cm (1.8 and 3.6 kilograms or 4 and 8 pounds).

In 1972, an eastern Pacific purse seiner, M/V Kerri M., with partial support from NMFS, conducted an exploratory 3-week fishing trip to the Marquesas. Briefly, most of the tuna schools sighted by the Kerri M. were composed of skipjack tuna. The estimated school size ranged from a few tons to something in excess of 100 tons. The skipjack tuna caught by the Kerri M. ranged from 8 to 12 pounds and the yellowfin tuna from 8 to 15 pounds. Nine successful sets (i.e., sets in which more than one ton of fish were caught) were made in a total of 37 attempted. A total of 87 tons (85 tons of skipjack tuna and 2 tons of yellowfin tuna) of tuna was caught. Two sets produced 20 and 35 tons, respectively, and the other seven sets produced six tons or less. The Kerri M.'s experience with the behavior of the fish schools was similar to that experienced earlier by our research vessels. The schools were erratic and unpredictable in their movements.

There have been reports of other purse seiners fishing in Marquesas waters but the results of these ventures have not been available to our Laboratory.

Literature Cited

Naughton, J. J.

- MS. Bird flock and surface tuna school sightings in the central Pacific Ocean, 1950-1972.

Rothschild, B. J., and R. N. Uchida

1968. The tuna resources of the oceanic regions of the Pacific Ocean. In The future of the fishing industry in the United States. University of Washington Publications in Fisheries, New Series.

Waldron, K. D.

1964. Fish schools and bird flocks in the central Pacific Ocean, 1950-1961. U.S. Fish Wildl. Serv., Spec. Sci. Rept.-Fish. No. 464.

Wilson, R. C., and T. S. Austin

1957. U.S. Fish and Wildlife Service task force in the Marquesas. Pan American Fisherman 11(12).

-
1959. Tuna season in the Marquesas. Pacific Fisherman, vol. 57(1).

Table 1.--Survey cruises conducted in the Marquesas Islands area by the National Marine Fisheries Service.

<u>Cruise</u>	<u>Date</u>	<u>Activity</u>	<u>Reported in</u>
<u>Hugh M. Smith 35</u>	August 1 - October 5, 1956	Oceanography	SSR-F 217
<u>Charles H. Gilbert 30</u>	August 6 - September 26, 1956	Longline and live bait fishing	"
<u>Hugh M. Smith 38</u>	January 11 - March 26, 1957	Oceanography	SSR-F 238
<u>Charles H. Gilbert 32</u>	January 11 - March 22, 1957	Live bait fishing	"
<u>John R. Manning 34</u>	January 4 - March 12, 1957	Longline fishing	"
<u>Charles H. Gilbert 35</u>	October 2 - December 14, 1957	Live bait fishing	SSR-F 283
<u>Hugh M. Smith 43</u>	January 3 - February 25, 1957	Live bait fishing	"
<u>Charles H. Gilbert 38</u>	February 7 - May 2, 1957	Live bait and longline fishing	"
<u>Hugh M. Smith 45</u>	March 28 - June 23, 1958	Live bait fishing	"
<u>Charles H. Gilbert 43</u>	January 7 - March 26, 1959	Live bait fishing	SSR-F 348
<u>Cape Falcon</u>	February 15 - March 15, 1959	Live bait fishing	"

X for May - 10/1/58

September 27, 1974

Mr. Wilvan G. Van Campen
NMFS Coordinator for PTDF
Southwest Fisheries Center
P. O. Box 271
La Jolla, California 92037

Dear Will:

In Richard Shomura's absence I'm sending you directly the Marquesas data you requested in your letter to him dated September 3. These are the environmental data; I understand you already have the biological info.

Enclosed are two copies each of charts I prepared showing (1) the summer mixed layer depth ("thermocline depth"), (2) permanent (winter) thermocline depth, (3) summer sea surface currents, and (4) winter sea surface currents. Also copies of the base chart, which is partially obscured by overlays on the first four charts.

The season selected, October-December, is of course the southern spring, when conditions will be shifting from winter to summer, so that currents, and thermocline topography, should be intermediate between the two extremes shown on the charts. Thermocline or mixed layer depths in particular should be affected; the summer thermocline topography does not develop until late spring. In any case, the summer thermocline is weak and probably does not have too much effect on the tunas' behavior, so the chart showing the permanent thermocline depth is probably the best one to use.

Sea surface currents around the Marquesas and Tuamotus are generally rather weak and variable, and only the climatic mean patterns can be shown on the charts. It will be wise to use these data with a few grains of salt in any case because observations are rather scarce in that part of the world.

Finally, you might want to look up SSR-F 238 and 283, PCFI reports on Marquesas cruises, which have quite a bit of data on weather, sea conditions, and such goodies as catch data and sightings of bird flocks and fish schools. SSR-F 283, in particular, covers the October-December period when the Gilbert was down there on cruise 35.

2

Mucha suerte, y felicitaciones por la nueva 'chamba.' Su atto.
y s.s.

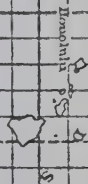
Sincerely,

Richard A. Barkley
Acting Director, Honolulu Laboratory

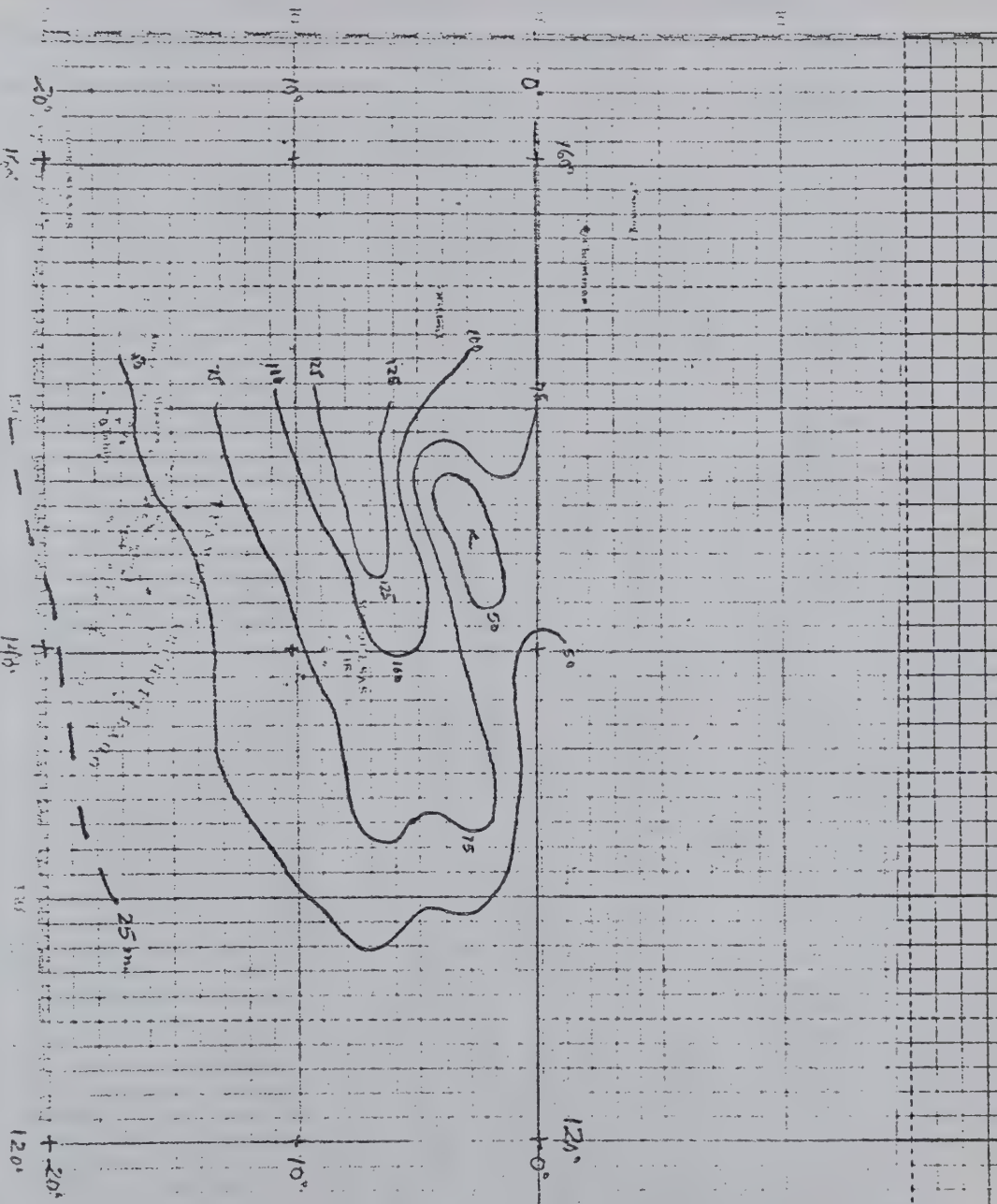
Enclosures

cc: Barkley
DO ✓

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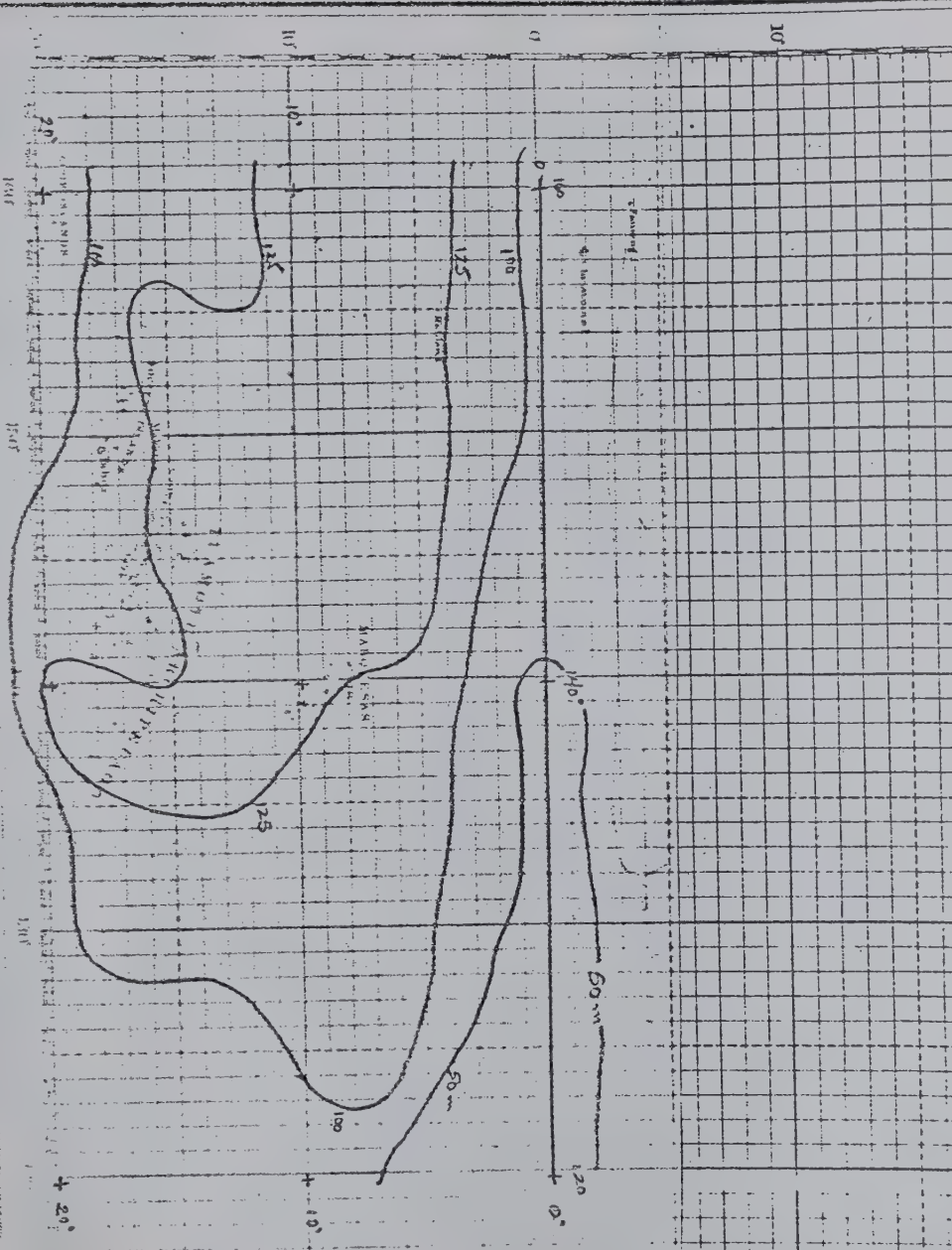
Location of study



Summers Mixed layer Depth

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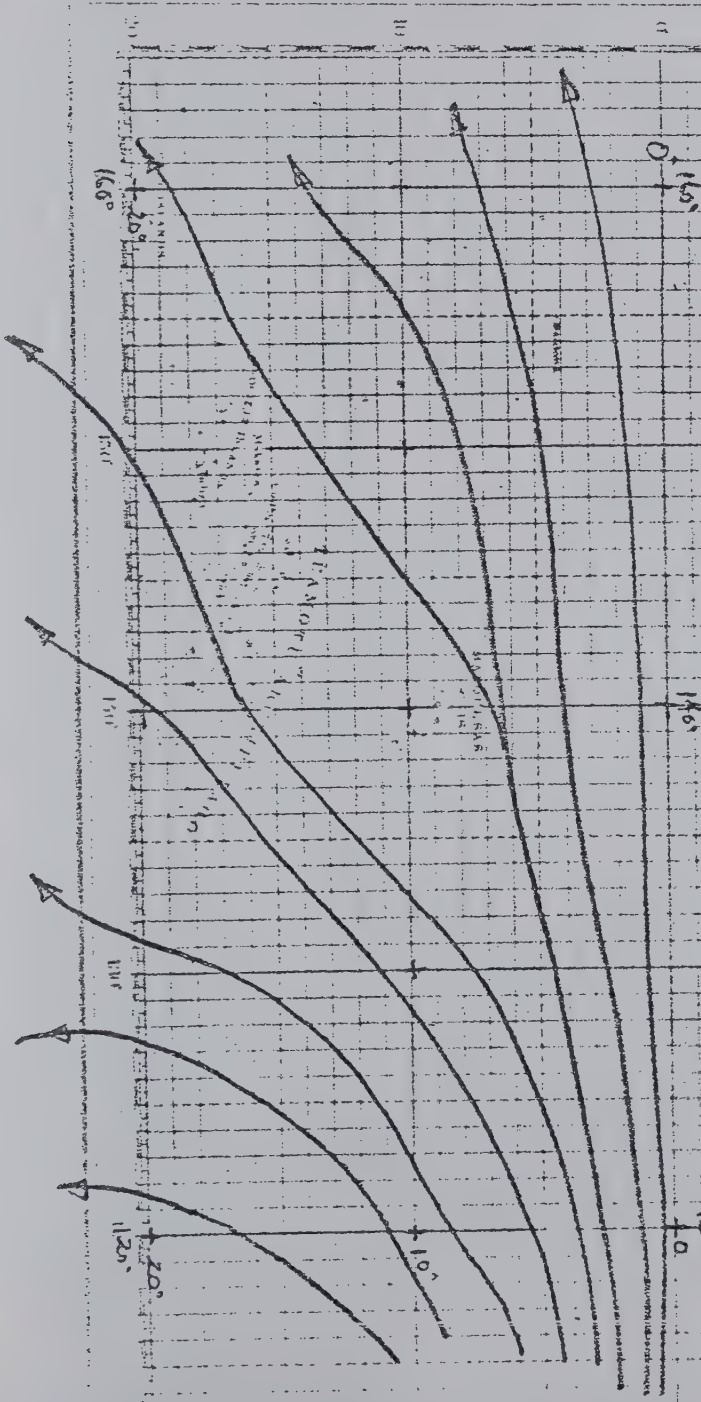


Permanent Thermocline

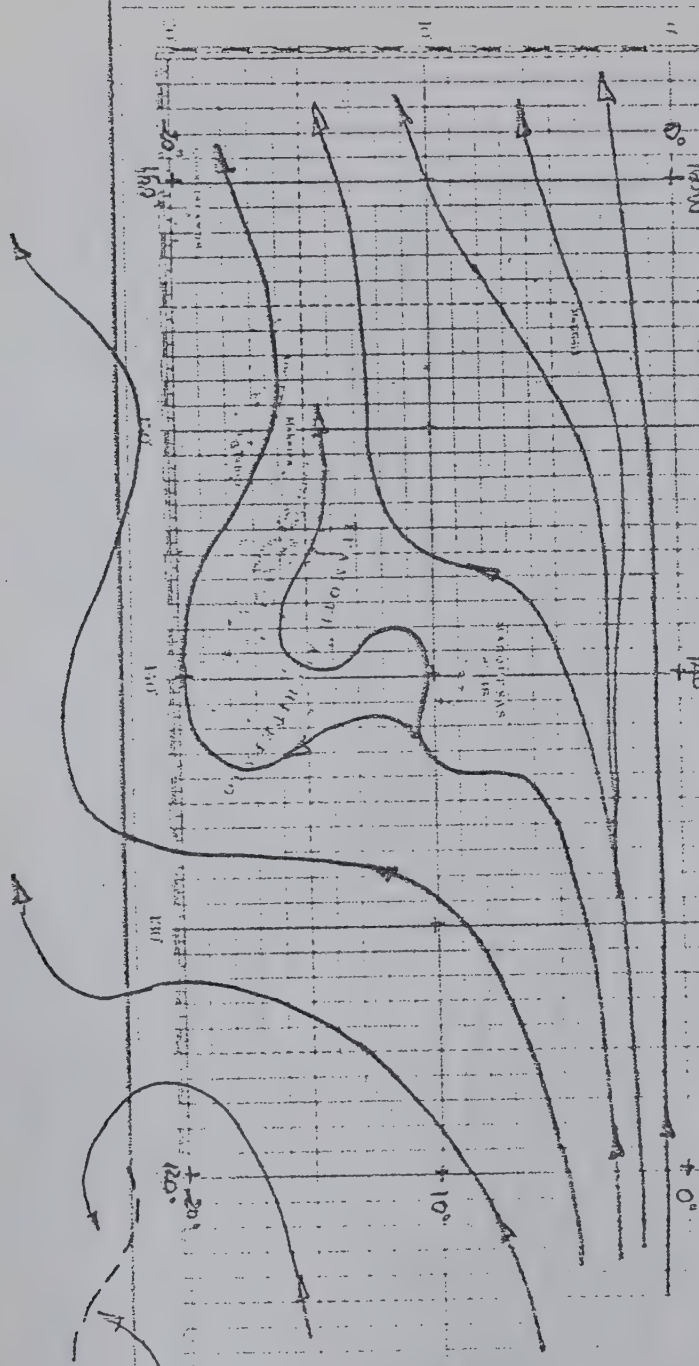


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Summer Sea Surface Currents



WINTER Sea Surface Currents



30°N
40°N

50°N

60°N

110°W

100°W
90°W
80°W

110°

120°W

110°W

100°W

90°W

80°W

70°W

60°W

50°W

40°W

30°W

20°W

10°W

0°

10°E

20°E

30°E

40°E

50°E

60°E

70°E

80°E

90°E

100°E

110°E

120°E

130°E

140°E

150°E

160°E

170°E

180°

170°W

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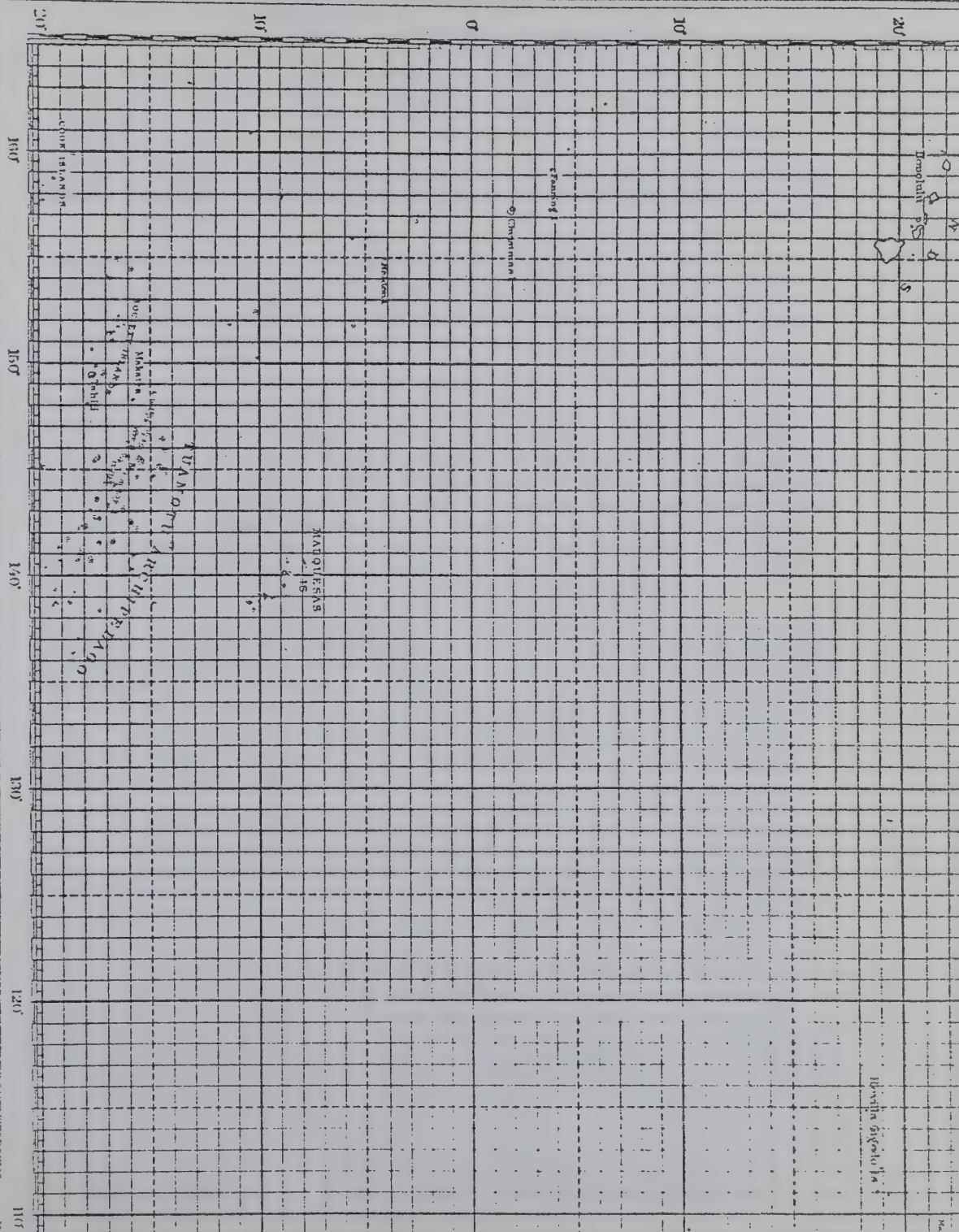
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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Fisheries Center
Honolulu and La Jolla Laboratories
P. O. Box 3830
Honolulu, Hawaii 96812

PROGRESS IN TUNA AND TUNA-RELATED STUDIES OF THE SOUTHWEST FISHERIES CENTER, HONOLULU LABORATORY, FROM OCTOBER 1973 THROUGH SEPTEMBER 1974

TUNA ASSESSMENT AND DEVELOPMENT INVESTIGATIONS

Design, Construction, and Testing of a Bait Transport System a Major Undertaking at the Honolulu Laboratory This Past Year

A limited supply of skipjack tuna baitfish has curtailed the growth of existing tuna fisheries and the establishment of new fisheries in areas of the Indo-Pacific. The SWFC Honolulu Laboratory is testing the feasibility of transporting baitfish from an area of plenty to one of limited supply. In a project under the leadership of Fishery Biologist Roger E. Green, the Laboratory developed a plan to augment the local bait supply in Hawaii by bringing the northern anchovy Engraulis mordax from California to the Hawaiian Islands using a transport tank via roll-on/roll-off freighter.

Late in October 1973 they acquired a surplus 5,000-gallon fuel tank and trailer, and began the design and construction necessary to modify it into a baitfish carrier. Tank modification and repairs were completed in January, as were final plans for the dual life support system, construction and installation of which were finished in March. The transporter was first tested with 45 buckets of threadfin shad, successfully carried from Wahiawa Reservoir to the Honolulu Laboratory's Kewalo Basin facility.

It was shipped to Long Beach in early April for its first load of anchovy. About 100 pounds of fish died during the crossing, but an estimated 500 pounds were delivered to Honolulu alive and well. A discharge system for the removal of dead fish and a new tank draining system were installed after the first load was removed.

For the second shipment the tank was loaded with an estimated 1,300 pounds of anchovy--later determined to be an overestimate. Fishery scientists in Honolulu had determined that a break-even payload should be a minimum of 700 pounds of baitfish. Loss during the second trial shipment was 450-500 pounds, removed dead and alive by the "vacuum cleaner" system of dead bait removal.

First results of live anchovy as skipjack tuna bait in Hawaii were reported by the skipjack tuna fishing vessel Anela. The anchovy were used to chum and fish 20-pound yellowfin tuna successfully but were felt to be too large for the 5- to 7-pound skipjack tuna in the islands at the time. The vessels selected to receive the second trial shipment reported excellent results chumming 8- to 15-pound skipjack tuna.

The third load delivered to Hawaii was small--the problem of accurately estimating the amount loaded becoming increasingly obvious.

In July a temporary baitfish aging facility was set up by SWFC and Southwest Region personnel in the Long Beach Harbor area, and about 2,000 pounds of strong, healthy baitfish were available for the fourth shipment. Of the 224 scoops of fish placed in the transport tank, 17 were weighed and a calculated mean weight estimated at 1,317 pounds. At the completion of the unmonitored voyage to Honolulu, over 400 pounds of anchovy in excellent condition were removed from the tanker. It was estimated that at least 800 pounds were lost overboard during the shipment, probably being expelled live through the after water outlet as the result of a greatly increased pressure head created by the angle of the tanker aboard the Matsonia.

Modifications to the tanker are presently underway in Long Beach, as are bait density tests being conducted by Messrs. Green and Aasted.

The South Pacific Albacore Fishery Provided Material for Various Studies Throughout the Reporting Year

The Fishery Analysis Program under the leadership of Dr. Robert Skillman continued the assessment of the South Pacific albacore fishery using data collected at the canneries in American Samoa. With the receipt of the final CY 1972 data, a total albacore catch for 1972 was determined to be 20,168 metric tons, less than the 1970 and 1971 catches of 23,876 and 22,193 metric tons, respectively. Effort expended by the fleet based in American Samoa increased slightly.

Dr. Skillman's group also worked on an analysis of the albacore size-frequency data collected from that part of the South Pacific albacore fishery based in American Samoa. These data were used to separate areas of homogeneous-sized fish in order to describe the size structure of the catch and to convert Japanese catch data in numbers to catch in weight. This analysis revealed a significant latitudinal effect on average size of albacore, with the largest fish occurring in the 15° to 20°S latitudinal band.

A sensitivity study of a recently developed generalized production model for the South Pacific albacore fishery was completed during the year. Data used in the study were the catch data from the fishery based in American Samoa, the non-Samoan catches for Japan as recorded in "Annual report of effort and catch statistics by area on Japanese tuna longline fishery," and refined estimates of the non-Samoan catches for Korea and Taiwan. This study concluded that the MSAY (maximum sustainable "average" yield) for the South Pacific albacore fishery as it is now carried out is about 35,000 metric tons.

Techniques of Otolith Reading Developed and Applied to Tuna Otoliths in Growth Rate Studies

Skills and techniques of otolith reading were developed in the first part of the reporting year with the reading of the presumed daily growth layers in sagittae of nehu, Stolephorus purpureus, from Pearl Harbor and Kaneohe Bay. Techniques thus developed were applied to the reading of otoliths taken from skipjack and yellowfin tunas of the central Pacific to determine early growth rates of these species. Skipjack tuna otoliths from the Papua New Guinea region were also examined in order to compare the growth rates of the geographical population from that area and the one from the central Pacific. Preliminary results suggest a slower growth rate for skipjack tuna from the Papua New Guinea area. A manuscript dealing with this subject is in preparation.

Expansion of Skipjack Tuna Fisheries in the Southwest Pacific and Around Adjacent Indian Ocean Islands Described After Extensive Literature Search

Fishery Biologist Richard Uchida completed an extensive literature search for data and information on the development or potential development of skipjack tuna fisheries, particularly in the southwest Pacific and around the islands of the Indian Ocean which are contiguous to the southwest Pacific. Gathered was catch, effort, and catch per effort information that was subsequently used to describe the expansion of the skipjack tuna fisheries in these areas.

Two Skipjack Tuna Tagged and Released in Eastern Pacific Recovered Near Hawaii

A tagged 8.38-kg skipjack tuna was recaptured in Hawaiian waters by the MV Sunfish on June 21, 1974. The fish had been tagged and released by IATTC on June 5, 1973 at lat. 22°00'N, long. 111°25'W. On August 30, 1974 about 30 miles south of Honolulu, the MV Buccaneer recovered a tagged skipjack tuna weighing 9.68 kg and measuring 75.0 cm FL. This second animal had been released at lat. 22°18'N, long. 111°39'W on June 8, 1973, at which time it measured 47 cm and weighed an estimated 2.03 kg (by Magnuson 1973 regression). The growth of

the second skipjack tuna closely approximates the growth curve for skipjack tuna in the central Pacific derived from Honolulu Laboratory measurements of skipjack tuna otoliths.

Prediction of the 1974 Skipjack Tuna Catch in the Hawaiian Fishery

In April Dr. Robert Skillman issued the 1974 Hawaiian skipjack tuna catch prediction of 3,800 metric tons. This estimate was based on a multiple linear regression model combining two earlier models, one based on the change in salinity from January 1 to March 1 of the year the catch is made, and the other on the time of minimum sea-surface temperature, all values collected at Koko Head, Oahu. Estimated cumulative state landings through September 16 were 2,596 metric tons.

FISH-ENVIRONMENT INVESTIGATIONS

Design and Construction of the Tuna Behavioral Thermoregulation System (the Doughnut Tank) Completed During the Reporting Period

During the reporting period Drs. William H. Neill and Andrew E. Dizon of the Honolulu Laboratory continued development of a unique apparatus for the study of tuna behavior in gentle temperature gradients like those encountered in much of the open sea. This apparatus, termed the tuna behavioral thermoregulation system, consists of a doughnut-shaped tank (8,000 liters) whose temperature is controlled automatically by a tuna's direction and speed of swimming in the circular channel. By reversing swimming direction in the tank, the tuna can keep the water within a preferred range of temperature. Anticipated results of these studies include the behavior of tunas in different temperature regimes and tunas' preferred temperatures, a set of parameters with high potential value in predicting tuna distribution in the ocean.

Construction of the system was completed in February except for two undelivered components, the refrigeration unit and the heater-switching assembly. During May the thermoregulation system's temperature-controlling parts were installed and tested.

First Output Obtained From a Simulation Model for the Responses of Fishes to Temperature

The long-range goal of the Honolulu Laboratory's program on Life Studies of Tuna and Tunalike Fishes is to generate a predictive model of tuna distribution, abundance, and availability to fisheries. The basis of the model is to be the joint physiological and behavioral responses of tunas to environmental variables, as determined in part through experimental work with captive fishes.

To explore the potential value of such a modeling approach and to provide an objective framework for further experimental work, Drs. William H. Neill and Andrew E. Dizon have developed a simulation model for the responses of fishes to temperature, a variable of recognized importance in the ecology not only of tunas but also of fishes in general.

The procedure used in constructing the model was 1) to create a hypothetical tunalike fish (based on skipjack tuna) endowed with a simple set of capabilities and responses, all well recognized or reasonably deducible from extant experimental results; 2) "follow" the fish in computer-generated one-dimensional environments with temperature the only variable; and 3) look for consistencies between distributional features of the hypothetical fish and those reported for real tunas in real heterothermal environments. Physiological acclimation, accumulation and decay of thermal "doses" leading to lethal-temperature mortality, temperature preference, gradient perception, and basal swimming speed were treated deterministically; perception-contingent increases in swimming speed and the tendency to change swimming direction were modeled stochastically as a biased random walk with constant step-time (10-min., in most simulations).

First runs of the model (without any a posteriori manipulation of process functions or input parameters) suggested a number of similarities between the behavior of the model and that of real tunas as observed at sea:

Hypothetical 50 cm long fish weighing 2 kg

- 1) tended to "seek out" and remain within a few degrees of their preferred temperatures in a linear gradient as steep as $1^{\circ}\text{C}/\text{km}$ but to randomly disperse in gradients of 0.1 or $0.01^{\circ}\text{C}/\text{km}$ until encountering temperatures near the upper or lower lethal limits;
- 2) tended to "aggregate" at randomly encountered thermal fronts, regardless of temperature;
- 3) would tend to become "trapped" and concentrated in areas of unfavorable temperature under certain conditions of temporal change in the distribution of temperature; similarly, would tend to be absent from areas of favorable temperature under certain conditions of temporal change in the distribution of water temperature;
- 4) would tend to be distributed within narrower thermal limits than conspecific fish of smaller size.

Doughnut Tank Experiments Investigate the Activity of Tunas in Rapidly Cooling Water

One notion implicit in the simulation model is that the likelihood of fish responding to a gradient of temperature depends both on the level and the rate of change of temperature. The faster the rate of change of temperature ($dT/ds \cdot ds/dt = dT/dt$) and the nearer the temperature to the lethal, the more likely is the fish to respond.

Drs. Dizon and Neill conducted a series of cooling experiments in the doughnut tank to establish such responses for tunas. Water temperature was decreased from 27°C at about 0.05°C min⁻¹ while swimming speed and turning tendency of the tunas were monitored.

Experiments with eight skipjack and two yellowfin tunas have been conducted. Both species consistently and dramatically increased their rate of turning when tank temperature decreased to 21.5°-20.5°. However, swimming speed of skipjack tuna tended to be almost constant between 27° and 19°C, whereas yellowfin tuna swam slower ($Q_{10} \approx 2.2$) as the water cooled.

Implications of Thermal Physiology on Distribution of Skipjack Tuna

In June Dr. William H. Neill of the Honolulu Laboratory reported construction of a tentative energy budget for central Pacific skipjack tuna; development of the budget was a collaborative effort by Drs. James F. Kitchell and John J. Magnuson of the University of Wisconsin and Dr. Neill. The energetics model suggested the following ecological proposition: Skipjack tuna smaller than about 12 kg are growing at rates substantially less than maximal, being limited by availability of food and/or predatory efficiency; skipjack tuna larger than about 15 kg obtain a maximum daily ration but are limited in further growth by a physiological constraint of large size coupled with an effective mechanism of heat retention--overheating of the muscle mass, especially during bursts of feeding activity.

Dr. Neill has now completed a preliminary analysis of the overheating problem. If it is assumed that 35°C is the temperature at which skipjack tuna muscle breaks down when exposed over a period of time, then it is possible to calculate maximum water temperatures at which skipjack tuna can safely operate (without regulation of heat exchange efficiency). At minimum activity, the red muscle of skipjack tuna metabolizes at about 1 mg-O₂ g⁻¹ hr⁻¹; the corresponding rate of demand for maximum activity is about 7 mg-O₂ g⁻¹ hr⁻¹, part of which must be met anaerobically.

The preliminary analysis suggested the following conclusions: Skipjack tuna larger than 12.5 kg cannot indefinitely sustain minimum activity in waters warmer than 30°C. At 5 kg, the critical temperature for minimum activity is about 31.5°C. But of more concern are the water temperatures critical for normally active fish, whose red muscle may metabolize at about $3 \text{ mg-O}_2 \text{ g}^{-1} \text{ hr}^{-1}$: 30°C at 1 kg, 25°C at 5 kg, and 20°C at 12.5 kg.

These calculations imply that large fish must seek out cooler waters if they are to be as active as smaller fish. This could be achieved by large fish living at higher latitudes or at greater depths than smaller fish. Low rates of heat exchange in large skipjack tuna permit forays of several minutes' duration into surface waters warmer than the critical temperature if the fish is initially at thermal equilibrium with deeper, cooler water.

Prerequisite to serious consideration of fish-energetics problems is accurate estimation of tissue caloric yields for the subject species. To complement construction of an energy budget for skipjack tuna, Drs. Kitchell, Magnuson, and Neill completed a caloric analysis of whole body, red muscle, and white muscle of just-caught and 10-day starved skipjack tuna.

Just-caught skipjack tuna, weighing 1.5 kg, had whole body averages of 1.46 kcal g-wet⁻¹, 5.00 kcal g-dry⁻¹, and 5.63 kcal g-ash-free-dry⁻¹, with water constituting 70.8% of wet weight. Skipjack tuna of similar size and history but starved for 10 days in captivity had whole body averages of 1.18 kcal g-wet⁻¹, 4.64 kcal g-dry⁻¹, and 5.36 kcal g-ash-free-dry⁻¹, with water constituting 74.7% of wet weight. Red muscle and white muscle showed the same trends as whole body, but decreases in kcal g-dry⁻¹ and kcal g-ash-free-dry⁻¹ for the two muscle tissues were only 25% in red muscle, and 5% in white muscle, as great as for whole body. Priority utilization of high-energy materials (fats) stored in the viscera presumably accounted for the dramatic changes in whole-body energy content during starvation.

Thus, skipjack tuna tissues yield substantially more than 1 kcal g-wet⁻¹, and, upon starvation, skipjack tuna not only metabolize their energy stores, in order of decreasing energy yield, but also hydrate.

Effects of Temperature on Routine Metabolism of Skipjack Tuna

Productivity of the seas in terms of tuna flesh must depend on whether food supplies are adequate to provide the energy required by tunas for activity and growth. Research Assistants Randolph Chang and Bernard Ito, under the supervision of Dr. William Neill, all of the Honolulu Laboratory, are extending previously completed experiments on routine metabolism of skipjack tuna at a single temperature (24°C)

to temperatures throughout the skipjack tuna's zone of thermal tolerance. This will permit estimation of the energy required for minimum activity in skipjack tuna at all temperatures where the fish are likely to occur.

Experiments at 18°, 24°, and 29°C have now been completed. Results can be summarized as follows:

Temperature (°C)	Number of tests	Respiration rate (mg-O ₂ g ⁻¹ hr ⁻¹)	
		Median	Range
18	14	0.66	0.42-1.03
24	6	0.71	0.58-0.79
29	10	0.78	0.64-1.25

Thus, routine metabolism of skipjack tuna appears only weakly temperature-dependent, the Q_{10} value being between 1.1 and 1.2.

Physiological Data Suggest Definition of Limits of Skipjack Tuna Habitat

Physiological data obtained recently in experiments and simulation studies conducted by the Life Studies Program of the Honolulu Laboratory are being used to shape answers to the long standing question of why there are no big skipjack tuna in the eastern Pacific Ocean. These data are being used to define the geographic areas the skipjack tuna can be expected to inhabit on the basis of extremes in tolerance. Results so far indicate that the smaller skipjack tuna, less than 3 kg or 50 cm in size, can inhabit virtually all of the eastern tropical Pacific above the oxycline. Areas from which larger fish are excluded increase in size with the size of the fish. Fish weighing 8 kg, 70 cm long, are excluded from an area which extends from Cabo Corrientes or San Blas to 145°W, 10°N, and from there to Panama. Fish of intermediate size are excluded from most of this area, but can move north-south along a 100-mile corridor slightly offshore of Mexico, between the Gulf of Tehuantepec and the Gulf of California. This corridor probably closes seasonally, and may close entirely in some years.

TUNA BAITFISH WORKSHOP

Tuna Baitfish Workshop Held at SWFC Honolulu Laboratory

An invitational tuna baitfish workshop co-sponsored by the National Marine Fisheries Service and the University of Hawaii Sea Grant Program, was held at the NMFS Honolulu Laboratory June 4-6.

A major purpose of the workshop was to bring together all information gathered thus far on baitfish, with emphasis on tuna baitfish of the central and western Pacific, and to explore some of the basic questions needing clarification in the face of the proposed development and expansion of skipjack tuna live-bait fisheries in these areas of the Pacific.

Thirty-seven participants from the mainland United States, Hawaii, Japan, and islands of the western Pacific met first in general session, where they considered the essentials of a suitable baitfish for skipjack tuna pole-and-line fishing. These criteria were organized as "fisherman-related" and "tuna-related," and the final product of the session, chaired by Honolulu Laboratory Director Richard S. Shomura, was a comparison to one another of the more important baitfishes presently in use in various parts of the Pacific.

Workshop sessions dealt with natural stocks; cultured species; and baitfish transport, holding, and substitutes, with a discussion of the economics of each method of providing the bait necessary to a particular fishery.

The session on natural stocks was conducted by Dr. R. E. Kearney, Principal Biologist with the Department of Agriculture, Stock and Fisheries, Konedobu, Papua New Guinea. This group identified the principal natural baitfish resources of the Pacific as falling into three categories: the large stocks of Engraulis found in the eastern and extreme western Pacific--as off the mainland United States west coast and off Japan--adequate for local fisheries and in addition available for transport; smaller stocks of other baitfishes, mainly Stolephorus, currently supporting modest stable or growing local skipjack tuna fisheries (included here is the Hawaii fishery, where nehu, S. purpureus, is the principal baitfish); and stocks known to be poor or not well enough known to be evaluated accurately. The group recommended improved bait handling and holding techniques, and intensified acquisition and exchange of information on naturally occurring stocks.

The session on cultured baitfish species, under the leadership of Mr. Shomura, aimed at providing guidelines for subsequent actions in the development of baitfish culture. The complexity of the subject was noted, and long- and short-range proposed approaches were aired. The group prepared a chart outlining the principal factors to be considered in the culture of known tuna baitfish.

Honolulu Laboratory Fishery Biologist Tamio Otsu opened the session on baitfish transport, holding, and substitutes stressing the need to establish direction and guidelines for ongoing baitfish transport studies presently being conducted by the NMFS Honolulu Laboratory. Discussion of problems of the experimental bait transport system centered on heavy mortalities experienced and on the importance of aging

the bait before shipping. The group approved of HL's approach to bait transport, and recommended a third trial shipment in the existing tank before undertaking an evaluation of tank design. Cost factors clearly affect the design and construction of a tank of "ideal" configuration.

In the final general session, participants established an order of priority for further studies: for Hawaii, the anchovy transport system; for American Samoa, the culturing and sea trials of mollies; initiation of Apogon studies by the Trust Territory of the Pacific Islands; and for other areas, the development of cultured baitfish and natural stocks.

The 35 contributed working papers constitute a valuable collection of current baitfish knowledge, and proceedings and selected working papers of the workshop will be published.

Attachment

September 17, 1974

HONOLULU LABORATORY PUBLICATIONS
ON TUNA AND TUNA-RELATED STUDIES

October 1973 through September 1974

TUNA AND TUNA-RELATED PUBLICATIONS

Hester, Frank J. 1974. Some considerations of the problems associated with the use of live bait for catching tunas in the tropical Pacific Ocean. U.S. Natl. Mar. Fish. Serv., Mar. Fish. Rev. 36(5):1-12. (MFR paper 1060.)

Matsumoto, Walter M. 1974. The skipjack tuna, Katsuwonus pelamis, an underutilized resource. U.S. Natl. Mar. Fish. Serv., Mar. Fish. Rev. 36(8):26-33. (MFR paper 1077.)

Neill, William H., and E. Don Stevens. 1974. Thermal inertia versus thermoregulation in "warm" turtles and tunas. Science (Wash., D.C.) 184:1008-1010.

IN PRESS

Dizon, Andrew E., E. Don Stevens, William H. Neill, and John J. Magnuson. Sensitivity of restrained skipjack tuna (Katsuwonus pelamis) to abrupt increases in temperature. Comp. Biochem. Physiol.

TRANSLATIONS

Federation of Japan Tuna Fisheries Co-operative Associations and Japan Tuna Fisheries Federation. 1972. Study of bait problems in the skipjack tuna and tuna fisheries (Katsuo-maguro gyogyo no jiryo taisaku). Federation of Japan Tuna Fisheries Co-operative Associations and Japan Tuna Fisheries Federation (Katsuo to Maguro) 126:4-8. February 1972. (Translated from Japanese by T. Otsu, 1974, 6 p.)

Horikawa, Akio. 1974. Japan's tuna production (Waga kuni no maguro gyogyo seisan). Suisan Shūhō (The Fishing and Food Industry Weekly) 707:16-19. March 25, 1974. Suisansha K.K. (Translated from Japanese by T. Otsu, 1974, 7 p.)

Katsuo-Maguro Nenkan. 1973. Japanese skipjack tuna fishery development in foreign areas (Katsuo kaihatsu--kaigai katsuo-zuri gyogyo). Katsuo-Maguro Nenkan (Skipjack-Tuna Yearbook). Suisan Shinchōsa K.K., Tokyo, p. 151-158. (Translated from Japanese by T. Otsu, 1974, 12 p.)

- Kikawa, Shoji. 1971. Shunyo Maru's third bait survey in the Papua New Guinea area (Shunyo Maru ni yoru dai-san-ji Papua New Guinea jiryogyo chosa). Proceedings of the 1970 Japanese Tuna Fishery Research Conference, Shimizu, Japan, February 3-5, 1971, p. 255-262. Fisheries Agency of Japan, Far Seas Fisheries Research Laboratory. (Translated from Japanese by T. Otsu, 1974, 10 p.)
- Kinki University Fishery Experimental Station. 1974. Artificial fertilization and rearing experiments conducted on tunas in 1973...A progress report (Showa 48-nendo maguro-rui fuka shi-iku gijutsu kaizen shiken hōkoku-sho). Preliminary progress report prepared for a special meeting of cooperating agencies working on tuna culture research, Shimizu, Japan, February 26, 1974, 23 p. (Mimeogr.) (Translated from Japanese by T. Otsu, 1974, 18 p.)
- Suisan Sekai. 1973. Tuna longliner No. 18 Nankai Maru [408 tons] earns a record 300 million yen[\$1.15 million] in a single trip... breaks record formerly held by the No. 5 Fukuhisa Maru [404 tons]. Suisan Sekai 22(2):46-50, February 1973. (Translated from Japanese by T. Otsu, 1973, 2 p.)
1973. No. 7 and No. 8 Otoshiro Maru (Mie Prefecture) make good albacore landings. Suisan Sekai 22(7):48-51. July 1973. (Translated from Japanese by T. Otsu, 1973, 5 p.)
- Suisan Shūhō. 1973. The slow progress in skipjack tuna live-bait development (Nakanaka susumanai katsuo no esa kaihatsu). Suisan Shūhō (The Fishing and Food Industry Weekly) 693:30-31. October 5, 1973. (Translated from Japanese by T. Otsu, 1973, 4 p.)
- Tohoku Regional Fisheries Research Laboratory. n.d. Atlas of skipjack tuna fishing grounds in southern waters, 1973 fishing season (July 1973-May 1974) (Showa 48 nendo nanpō katsuo gyokyo). [Five pages text, 14 charts.] (Translated from Japanese by T. Otsu, 1974, 22 p.)
- Urabe, Shiro (interviewer). 1974. There's a keen interest in developing new skipjack tuna fishing grounds (Shingyojo no kaihatsu ni iyoku wo moyasu). Suisan Sekai 23(1):84-93. [Interview with two brothers, both fishing masters on vessels belonging to the Abekane Suisan K.K.] (Translated from Japanese of selected portions of article by T. Otsu, 1974, 17 p.)

HAWAII'S FRESH FISH INDUSTRY--A "SHOPPING LIST"

FOR FY 1975 SEA GRANT

Prepared by

Richard S. Shomura¹
Member, Sea Grant Advisory Committee

September 18, 1974

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Report prepared for University of Hawaii Sea Grant Advisory Group.

HAWAII'S FRESH FISH INDUSTRY--
A "SHOPPING LIST" FOR FY 75 SEA GRANT

The following provides a "first cut" list of projects that Sea Grant may wish to have investigators consider for support in FY 75:

Resource Survey and Assessment

1. Conduct assessment studies of the commercially important insular species, e.g., akule, opakapaka, kumu.

Comment: The development and management of the fishery resources will depend largely on having a good understanding of the population dynamics of the resource base.

2. Conduct a survey and assessment of the insular resources of the northwest Hawaiian Islands.

Comment: The northwest Hawaiian Islands represents the area with the greatest potential for increased production of food fishes in the Hawaiian Islands area. To date, much of the area has not been fished actively. There is a need for a good data base in order to work out a meaningful development and management system.

A full scale survey and assessment program will provide an opportunity to conduct a multitude of biological and ecological study of the marine fauna and flora.

Fishery Development

1. Evaluate the economics and utility of threadfin shad as a baitfish supplement for the local skipjack tuna fishery.

Comment: At a baitfish workshop held in June 1974 and sponsored by the National Marine Fisheries Service and the University of Hawaii Sea Grant Office, one of the recommendations resulting from the meeting was to further explore the use of threadfin shad as a baitfish supplement for the local skipjack tuna fishery.

2. Evaluate the use of golden shiners as a suitable baitfish species for use by the local skipjack tuna fishery.

Comment: The golden shiner has been suggested as having the characteristics of a good baitfish species for tuna fishing. The results of several trials carried out on Maui in 1973 suggest that further extensive trials are warranted. The culture techniques of the golden shiner are well known; however, the necessity of keeping this species in fresh water makes its application for distant water fishing limited. If suitable as a baitfish, its use may be the solution for coastal skipjack tuna fishing of short durations.

3. Develop a suitable trap for catching commercial quantities of insular species found in deep water, e.g., 100-200 fathoms.

Comment: Although fish traps are not used extensively in the Hawaiian Islands, the method may prove to be superior to the hand line method in catching insular species found in deep waters.

Economic Studies

1. Conduct an economic study of the akule fishery to determine expansion potentials of this fishery.

Comment: The akule fishery is the largest volume inshore fishery in Hawaii. The large increase in landings during the past decade has been accompanied by a drop in average ex-vessel price. Possibly the development of alternate markets for the akule, e.g., frozen fish product, may provide the mechanism for price stabilization and a further development of the fishery.

2. Conduct an in-depth study of the per capita consumption of fish and fishery products in Hawaii.

Comment: The feasibility of an expansion of the Hawaiian fisheries for domestic consumption is to some extent dependent upon the current eating habits of the local population. Considering the alternative food stuffs, e.g., meat and poultry, it may be that the Hawaiian populace is already eating a considerable quantity of fish and fishery products. Under these conditions a further expansion of the fishery may be difficult and could possibly be directed only toward an increase in domestic caught fish at the expense of imported fish products.

3. Conduct a study of the amount of fish and fishery products imported by Hawaii.

Comment: Much of the fish and fishery products consumed in Hawaii are imported. A study of the amount and types of fish and fishery products imported should provide clues as to what areas of the Hawaiian fisheries could be expanded or developed.

This project could be conducted as one phase of project 2 listed above.

Food Technology

1. Conduct studies to extend the shelf life of skipjack tuna.

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Food Technology

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Comment: Skipjack tuna as a fresh fish commodity has a reputation for a short shelf life. This is especially true when compared to other tuna species, e.g., yellowfin and bigeye tunas. Deterioration is evidenced by tissue transforming into canals of gelatinous material. With the demand for tunas increasing on the world market and the skipjack tuna the only commercial tuna species considered to be underutilized, an extension of the shelf life would provide the basis for an expanded fresh fish market, e.g., export of large skipjack tuna to Japan for the highly prized sashimi market.

2. Determine the cause of "burning" in tunas.

Comment: The local tuna industry currently encounters a loss of fish sales due to a "burnt" condition found in the flesh of some yellowfin and bigeye tunas. The phenomenon is especially prevalent in the tunas that are caught by the hand line technique. This technique is mostly used on the island of Hawaii. This condition makes the fish unsuitable for sale as sashimi.

3. Compile and develop recipes utilizing Hawaiian fresh fishes.

Comment: Hawaii's population is composed of people representing a diverse ethnic background. This diversity is reflected in the unusual and exotic ways in which food, including fish, are prepared in Hawaii. A collection of "Hawaiian" recipes for the preparation of fish would probably find acceptance not only in Hawaii but also on the mainland. This work would include compiling recipes that are well known and widely used, the "development" of new recipes, and the "discovery" of new recipes by running contests, etc.

Others

1. Conduct a study of the barriers to the full utilization of Hawaii's fishery resources and develop a systems analysis of alternative development strategies.

Comment: An overview study of the Hawaiian fisheries scene may reveal the critical areas which retard full utilization. A systems approach would provide a rational guideline for implementation.

2. Develop public policies for the development and management of the northwest Hawaiian Island marine resources.

Comment: Since extensive harvesting of the marine fishery resources has not yet taken place, this may be an opportune time for the State to develop sound policies.

3. A study of the commercial fishing licensing and enforcement system in Hawaii.

Comment: One of the criticisms presented by full time commercial fishermen is that the low license fee permits too many part time fishermen to enter the fishery and compete with them for the limited market. Additionally, an unknown but reportedly substantial amount of fish is entering the commercial markets via fishermen without a commercial license. An in-depth study may lead to a system of licensing which would lead to a better managed fishery and provide the State with its due license and tax proceeds.

FURTHER INVESTIGATIONS ON THE POPULATION DYNAMICS
OF THE SOUTH PACIFIC ALBACORE FISHERY¹

By

ROBERT A. SKILLMAN

Southwest Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
Honolulu, Hawaii 96812

SEPTEMBER 1974

¹A report submitted to the Director, Honolulu Laboratory, and to the Director, Southwest Fisheries Center, National Marine Fisheries Service, NOAA.

INTRODUCTION

In early 1974, I made an assessment of the South Pacific albacore fishery (Skillman, MS²) utilizing the generalized production model of Pella and Tomlinson (1969) in response to U.S. industry plans to expand cannery capacity in the South Pacific. Utilizing fishing effort measured both in hooks and days fished, the maximum sustainable "average" yield (MSAY) was estimated to be 33,000-35,000 metric tons (MT).

A number of simplifying assumptions were made regarding the validity of catch and catch per unit effort (CPUE) data in order to produce the assessment on a timely basis. In this report, I investigated the validity of the estimates of total catch for the South Pacific and the potential effect of changes in primary species sought as well as changes in nationality of the fleet operating out of American Samoa as these changes would affect the estimation of CPUE, total effective effort, and MSAY.

TOTAL CATCH

In Skillman (MS²), total catch estimates were compiled from cannery records for the operations in American Samoa, from various issues of the "Annual report on effort and catch statistics by area on Japanese tuna longline fishery" for Japanese catches made by vessels stations at foreign bases in the South Pacific (less Samoan catches) and by "home-based" vessels fishing in the South Pacific, and from various issues of reports by the Federation of Japan Tuna Fisheries Co-operative Associations and Japan Tuna Fishermen's Cooperative Association (referred to as the Asian Tuna Conference Proceedings in the remainder of this paper) for non-Samoan catches by Korean and Taiwanese vessels in the South Pacific. I considered the data from the first two sources as complete and accurate, but regarded data from the last source as approximate. In this paper, I investigated the effect of different estimates of non-Samoan catches of albacore by Korean and Taiwanese vessels on the estimation of MSAY.

In a previous study, non-Samoan catches of albacore by Korean and Taiwanese vessels were estimated from the Asian Tuna Conference Proceedings by incorporating the following assumptions:

²Skillman, R. A. An assessment of the South Pacific albacore, Thunnus alalunga, fishery, 1953-72. Manuscript in preparation. Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.

1. That catches reported for the "Pacific" were entirely for the South Pacific;
2. That the reported catches were complete, that is, 100% of the actual landings for all foreign bases as well as for any home-based vessels;
3. That the proportion of albacore in the landings of a given nation for the entire "Pacific" applied to the total catch data given by foreign base but with no species breakdown;
4. That the reported or calculated albacore catches less known Samoan catches (NMFS data) equaled the catch in the remainder of the South Pacific.

In this paper, non-Samoan albacore catches were estimated using the reported number of vessels fishing by foreign base as given in the Asian Tuna Conference Proceedings. It was possible to use reported number of trips for Taiwan, but not for Korea. The following steps were followed:

1. Determined the error in reporting of vessels fishing in American Samoa for Korea and Taiwan and expressed this as a "raising factor;" the raising factor for Korean vessels for some years was less than 1;
2. Used the calculated raising factors to correct the reported number of Korean and Taiwanese vessels fishing out of other foreign bases;
3. Estimated catch per vessel for Korean and Taiwanese vessels based on NMFS' Samoan data;
4. Calculated estimated catch by foreign base for Korea and Taiwan using Samoan catch/vessel;
5. Summed estimates to obtain total albacore catch for the South Pacific.

These steps incorporated the following assumptions:

1. By using number of vessels as effort statistics, I assumed that the vessels at the different bases collectively had the same fishing power, which would be some mixture of fishing the same number of hooks per day per vessel, the same number of days per year, and the same species mixture as well as utilizing the same time-area fishing strategy;

2. That the number of vessels fishing out of American Samoa as determined from NMFS' records was exact;
3. That all South Pacific catches of albacore by Taiwan and Korea were made by vessels operating out of foreign bases;
4. That there existed the same degree of incorrect reporting of vessels fishing out of American Samoa as out of all other bases;
5. That catch/vessel by nation was identical for all foreign bases in the South Pacific.

When these new estimates for non-Samoan catches by Korea and Taiwan were combined with the remaining South Pacific catches, they compared with the total estimates from the first method as follows:

<u>Year</u>	<u>First</u>	<u>Second</u>	<u>Percent difference</u>	
1962	41,976	41,678	-0.7	Minimum
1963	39,020	38,412	-1.6	
1964	25,000	26,160	4.6	
1965	26,380	28,702	8.8	
1966	42,104	46,499	10.4	Maximum
1967	39,890	42,770	7.2	
1968	28,604	28,878	1.0	
1969	31,542	32,759	3.9	
1970	37,854	38,216	1.0	
1971	39,166	40,032	<u>2.2</u>	
			4.1	Average

These new estimates were used with the previously derived estimates of CPUE to calculate new estimates of total effective effort (Table 1). A generalized production model was then fitted to these new estimates of total catch and effective effort (Table 2). Results in this table, as well as in all subsequent tables of the generalized production model, were only for an averaging time of 3 years using Gulland's nonequilibrium adjustment technique, since this averaging time seemed to provide the best fit to the data.

The new estimates of MSAY (Table 2) were not significantly greater than the old estimates, though they were slightly larger. However, the shape of the sustained "average" yield curve changed drastically for the models using both effort in hooks and days fished. Using hooks fished, the sustainable yield curve changed

from being nearly asymptotic to being skewed (Gompertz type). Using days fished, the sustainable yield curve changed from a skewed curve to a curve with an abruptly dropping right limb. Thus, these calculations indicate that the population is more sensitive to fishing beyond the optimum level than was the case in the initial analysis.

In order to further investigate the sensitivity of the production model to errors in estimating non-Samoan catches, I incorporated corrections for hypothetical underestimates of 10%, 25%, and 50% for Korea and Taiwan non-Samoan catches. Fitting the generalized production model to these data resulted in an increase in estimated MSAY of about 690, 1,800, and 3,700 MT, respectively (Table 3). The shape of the sustainable "average" yield curves did not change appreciably.

To summarize the results in this section, fitting the generalized production model to a new set of total catch data that incorporated new estimates of non-Samoan catches, plus data sets that represented increases of these non-Samoan catches of 10%, 25%, and 50% resulted in estimates of MSAY of 35,000-38,700 MT, while the original estimates were 33,000-35,000 MT. Thus, even substantial errors in the most likely segment of the total catch data resulted in only about a 10% increase in MSAY.

SPECIES MIXTURE

It is generally felt by people familiar with the South Pacific albacore fishery that yellowfin tuna has become increasingly important as a secondary target species in the fishery. If the fleet in American Samoa has changed its gear to take more yellowfin tuna, then the effort statistics must be adjusted in order to keep the same relationship between effort and fishing mortality, as it applies to the albacore. In this section, I investigated the possibility of a temporal change in species mixture in the Samoan segment of the fishery.

While the proportion of albacore to yellowfin tuna declined from 1962 to 1972 (Figure 1), the catch of both species increased over this same time period (Figure 2). Neither of these trends indicated whether or not the fleet changed its gear and therefore the species sought. The yearly trends in CPUE for albacore and yellowfin tuna (Figure 3) suggested that while CPUE for albacore declined with time, that for yellowfin tuna did not. When the CPUE for albacore and yellowfin tuna were compared directly, there seemed to be no relationship between them (Figure 4). If the 1962 value was included, there seemed to be a significant negative correlation for Japanese vessels; but when the 1962 and 1963 data points for Japan were dropped in order to coincide with the years

available for Korea and Taiwan, a significant relationship did not exist for any single nation or for all nations pooled.

Therefore on a yearly basis, there was no evidence that the fishing fleet based in American Samoa had changed its gear in order to catch more yellowfin tuna. It caught more yellowfin tuna in the later years of the fishery because, as fishing effort increased, the catch rate for albacore declined markedly while that for yellowfin tuna remained stable. Hence, there was no need to standardize the effort statistics or to recalculate the generalized production model.

NATIONALITY OF THE FLEET

The national composition of the Samoan fleet has changed significantly over the history of the fishery. Japanese vessels were the first to enter, and they reached their greatest representation in 1963. They have now withdrawn from the Samoa-based fishery. Korean boats first entered the fishery in 1958 and Taiwan followed in 1964. Taiwanese vessels now dominate in numbers. There is the possibility that the fishing power of the fleet changed as inexperienced vessels entered the fishery and the veterans left. If this is true, pooling of the catch and effort data in order to calculate CPUE statistics would not be valid.

To investigate the possibility of differences in catch rate between nations, the yearly trends in CPUE given in Figure 3 (and others not included here) were studied for changes in the rank of one nation to another. No consistent trends were found between the various measures of CPUE. The CPUE statistics for Japan, Korea, and all nations pooled were so highly correlated (Table 4) that it should make no difference which statistic is used as the standard. CPUE for Taiwan was usually correlated with the other indexes but only at the 0.05 significance level; this was probably due to the first 3 years after Taiwan entered the fishery, at which time their catch rates did not agree well with those of the other nations.

Although the CPUE estimates were so highly correlated that it should have no significant influence on the estimation of MSAY, each of the national CPUE statistics was used as the standard in calculating the generalized production model. Table 5 gives the results of using the various estimates of CPUE with the original (A) and the new (B) estimates of total catch in the South Pacific. Some of the estimates of MSAY were less, some greater than those calculated using the pooled estimate of CPUE, but none were significantly different.

Therefore, the pooled estimate of CPUE as used in the initial assessment of the fishery provided nearly the same assessment of the stock as any other possible measure of CPUE based on nationality.

SEASONALITY

Since there is a marked seasonal trend in catch rate of albacore, it has been suggested that CPUE calculated over a time of peak catch rate may be a better measure of density or at least may provide a different picture of the state of the stock. Since June, July, and August are times of highest albacore catch rate, I calculated an average CPUE for each of these months. These averages were highly correlated with the yearly CPUE statistics ($r = 0.93^{**}$, d.f. = 8).

Hence, this peak season measure of CPUE did not show a different trend from any of the other measures of CPUE and should not lead to any significant differences in estimated MSAY (a generalized production model was not fitted to the data).

CONCLUSIONS

Having fitted generalized production models to two sets of total catch data utilizing different means of estimating non-Samoan catches of Korean and Taiwanese vessels, plus adding hypothetical 10%, 25%, and 50% corrections for underreporting of catches as well as investigating the use of nine different estimates of CPUE, and having determined thereby that there were no more than 2,000-4,000 MT differences in the estimation of MSAY, I have concluded that there is little to be gained by doing anymore generalized production model analyses. That is not to say that a yield per recruit analysis would not be beneficial, for example, in exploring the relatively low MSAY that has been predicted or in exploring ways of increasing the catch by manipulating the harvesting of specific age-classes. But I do not think that this kind of analysis is critical or urgent at this time.

LITERATURE CITED

- Pella, J. J., and P. K. Tomlinson.
1969. A generalized stock production model. Inter-Am. Trop.
Tuna Comm. Bull. 13:421-496.

Table 1.--Albacore catch in metric tons for the South Pacific Ocean. Estimates for non-Samoan catches were derived from the number of vessels reported in the Asian Tuna Conference Proceedings. Estimates of CPUE were calculated from all nations pooled in the fishery based in American Samoa.

Year	Category	Catch in metric tons				Catch per unit effort		Estimated total effective effort	
		Japan	Korea	Taiwan	Total	MT/10 ³ hooks	MT/day fished	Hooks (x10 ³)	Days
1962	Nation	28,352	--	--	28,352			19,067	17,334
	Am. Samoa	12,605	634	--	¹ 13,326	1.4870	1.6356	8,962	8,147
	Grand total	40,957	634	--	41,678			28,029	25,481
1963	Nation	23,762	--	--	23,762			24,665	19,775
	Am. Samoa	12,907	1,660	--	¹ 14,650	0.9634	1.2016	15,207	12,192
	Grand total	36,669	1,660	--	38,412			39,872	31,967
1964	Nation	14,136	1,233	--	15,369			18,233	13,705
	Am. Samoa	8,385	1,850	556	10,791	0.8429	1.1214	12,802	9,623
	Grand total	22,521	3,083	556	26,160			31,035	23,328
1965	Nation	10,871	2,373	--	13,244			17,096	12,776
	Am. Samoa	9,518	4,350	1,590	15,458	0.7747	1.0366	19,954	14,912
	Grand total	20,389	6,723	1,590	28,702			37,050	27,688
1966	Nation	16,534	3,152	1,243	20,929			23,946	19,635
	Am. Samoa	9,086	9,123	7,361	25,570	0.8740	1.0659	29,256	23,989
	Grand total	25,620	12,275	8,604	46,499			53,202	43,624
1967	Nation	9,670	3,257	1,532	14,459			19,710	15,091
	Am. Samoa	7,528	9,636	11,147	28,311	0.7336	0.9581	38,592	29,549
	Grand total	17,198	12,893	12,679	42,770			58,302	44,640
1968	Nation	5,413	2,570	3,172	11,155			20,216	15,707
	Am. Samoa	3,156	6,349	8,218	17,723	0.5518	0.7102	32,119	24,955
	Grand total	8,569	8,919	11,390	28,878			52,335	40,662
1969	Nation	4,489	2,645	6,894	14,028			24,211	17,800
	Am. Samoa	1,560	10,184	6,987	18,731	0.5794	0.7881	32,328	23,767
	Grand total	6,049	12,829	13,881	32,759			56,539	41,567
1970	Nation	5,598	2,506	6,236	14,340			25,207	16,626
	Am. Samoa	952	11,942	10,982	23,876	0.5689	0.8625	41,969	27,682
	Grand total	6,550	14,448	17,218	38,216			67,176	44,308
1971	Nation	6,437	2,491	8,910	17,838			32,634	24,844
	Am. Samoa	380	11,800	10,014	22,194	0.5466	0.7180	40,604	30,911
	Grand total	6,817	14,291	18,924	40,032			73,238	55,755

¹Includes undetermined nationality.

Table 2.--Generalized production model for South Pacific albacore using old and new catch estimates. $T_1 = 3$ years.

Data	$\hat{m}$	$\hat{CPUE}_{opt}$	$\hat{MSAY}$	$\hat{f}_{opt}$	MSQ
Days		<u>MT/day</u>	<u>10³ MT</u>	<u>10³ days</u>	<u>10⁻¹</u>
Old	1.62	0.791	33.072	41.801	0.0613
New	2.71 3.12	0.841 0.863	36.981 37.817	43.990 40.367	0.1820 0.0541
Hooks		<u>MT/10³ hooks</u>	<u>10³ MT</u>	<u>10³ hooks</u>	<u>10⁻¹</u>
Old	0.25	0.325	34.665	106.761	0.0769
New	1.11 1.27	0.551 0.570	36.999 34.277	67.137 60.152	0.0216 0.0952

Table 3.--Generalized production model for South Pacific albacore fishery. Catch data incorporated +10%, +25%, +50% corrections for Korea and Taiwan using "new" catch estimates.

Data	$\hat{m}$	$\hat{CPUE}_{opt}$	$\hat{MSAY}$	$\hat{f}_{opt}$	MSQ
Days		<u>MT/day</u>	<u>10³ MT</u>	<u>10³ days</u>	<u>10⁻¹</u>
"New"	3.12	0.863	37.817	40.367	0.0541
+10%	2.71	0.841	36.981	43.990	0.1820
+25%	2.87	0.845	35.380	41.890	0.0574
+50%	2.53	0.816	36.307	44.489	0.0617
	1.00	0.714	37.800	52.976	0.0567
Hooks		<u>MT/10³ hooks</u>	<u>10³ MT</u>	<u>10³ hooks</u>	<u>10⁻¹</u>
"New"	1.27	0.570	34.277	60.152	0.0952
+10%	1.11	0.551	36.999	67.137	0.0216
+25%	1.17	0.547	35.101	64.167	0.0952
+50%	1.03	0.513	36.464	71.145	0.0956
	0.99	0.484	38.697	79.944	0.0966

Table 4.--Simple (above diagonal) and partial (below diagonal) correlation coefficients for catch in metric tons per day for albacore and yellowfin tuna in the fishery based in American Samoa.

I. MT/day for albacore				
	Japan	Korea	Taiwan	All
Japan		0.8608 **	0.7181 *	0.9601 **
Korea	-0.6174 NS		0.5931 NS	0.9533 **
Taiwan	0.2153 NS	-0.0576 NS		0.6797 NS
All	0.8800 **	0.8914 *	0.0287 NS	

II. MT/day for yellowfin tuna				
	Japan	Korea	Taiwan	All
Japan		0.7001 *	0.2156 NS	0.6504 *
Korea	0.1462 NS		0.5895 NS	0.9027 **
Taiwan	-0.5338 NS	-0.2556 NS		0.7735 **
All	0.4396 NS	0.7111 NS	0.7621 NS	

Significance levels were tested at 0.05 and 0.01 and are indicated by * and **, respectively. NS = nonsignificance.

Table 5.--Comparison of the generalized production model using $\bar{T}_1 = 3.0$ years and different estimates of total effective effort based on estimates of CPUE by nation for the American Samoa fishery with A) total catch based on American Samoa, Japanese, and Asian Tuna Conference Proceedings (catch estimates) and B) total catch based on American Samoa, Japanese, and ATCP (number of vessels).

CPUE	$\hat{m}$	$\hat{CPUE}_{opt}$	$\hat{MSAY}$	$\hat{f}_{opt}$	MSQ
A. Catch estimates					
Days		<u>MT/day</u>	<u>10³ MT</u>	<u>10³ days</u>	<u>10⁻¹</u>
All nations	1.62	0.791	33.072	41.801	0.0613
Japan	2.10	0.924	32.915	35.630	0.0616
Korea	1.00	0.718	34.152	47.544	0.1776
Taiwan	5.20	0.836	34.443	41.219	0.0513
Hooks		<u>MT/10³</u>	<u>10³ MT</u>	<u>10⁶ hooks</u>	<u>10⁻¹</u>
All nations	0.25	0.325	34.665	106.761	0.0769
Japan	0.71	0.458	34.075	74.379	0.0486
Korea			-----No solution-----		
Taiwan	0.03	1.377	33.026	23.981	0.0610
B. Number of vessels					
Days		<u>MT/day</u>	<u>10³ MT</u>	<u>10³ days</u>	<u>10⁻¹</u>
All nations	3.12	0.863	34.817	40.367	0.0541
Japan	3.10	0.958	34.704	36.243	0.0562
Korea	0.51	0.438	34.329	78.309	0.1163
Taiwan			-----No solution-----		
Hooks		<u>MT/10³</u>	<u>10³ MT</u>	<u>10⁶ hooks</u>	<u>10⁻¹</u>
All nations	1.27	0.570	34.277	60.152	0.0950
Japan	1.75	0.573	34.721	60.574	0.0681
Korea	4.26	0.905	36.388	40.189	0.1430
Taiwan	0.21	0.211	37.653	17.881	0.0788

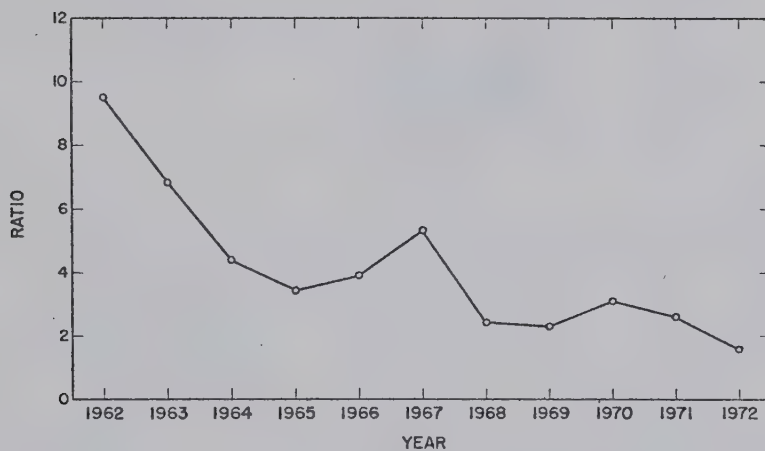


Figure 1.--Ratio of albacore to yellowfin tuna catches in metric tons for the fishery based in American Samoa.

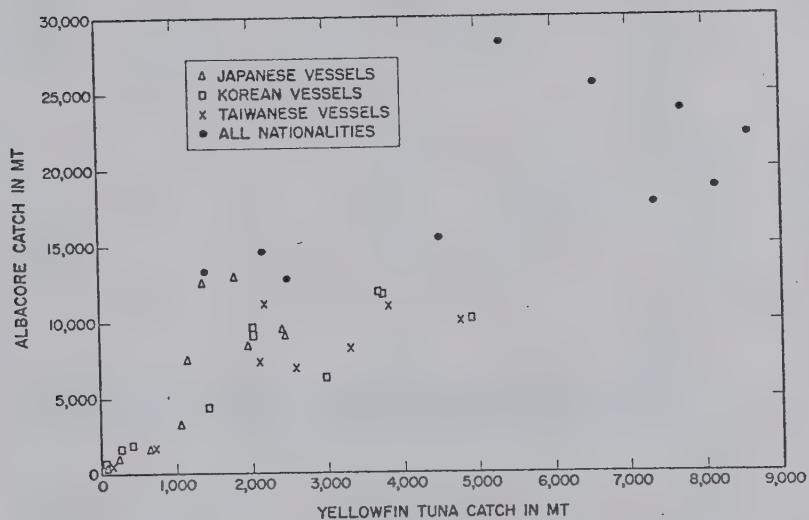


Figure 2.--Relationship between albacore and yellowfin tuna catches in metric tons for the fishery based in American Samoa. For catches made by Japanese, Korean, and Taiwanese vessels as well as vessels of all nationalities combined, the correlation coefficients are 0.80 ($P \leq 0.01$, d.f. = 8), 0.88 ($P \leq 0.01$, d.f. = 8), 0.84 ($P \leq 0.01$, d.f. = 6), and 0.65 ($P \leq 0.05$, d.f. = 8), respectively.

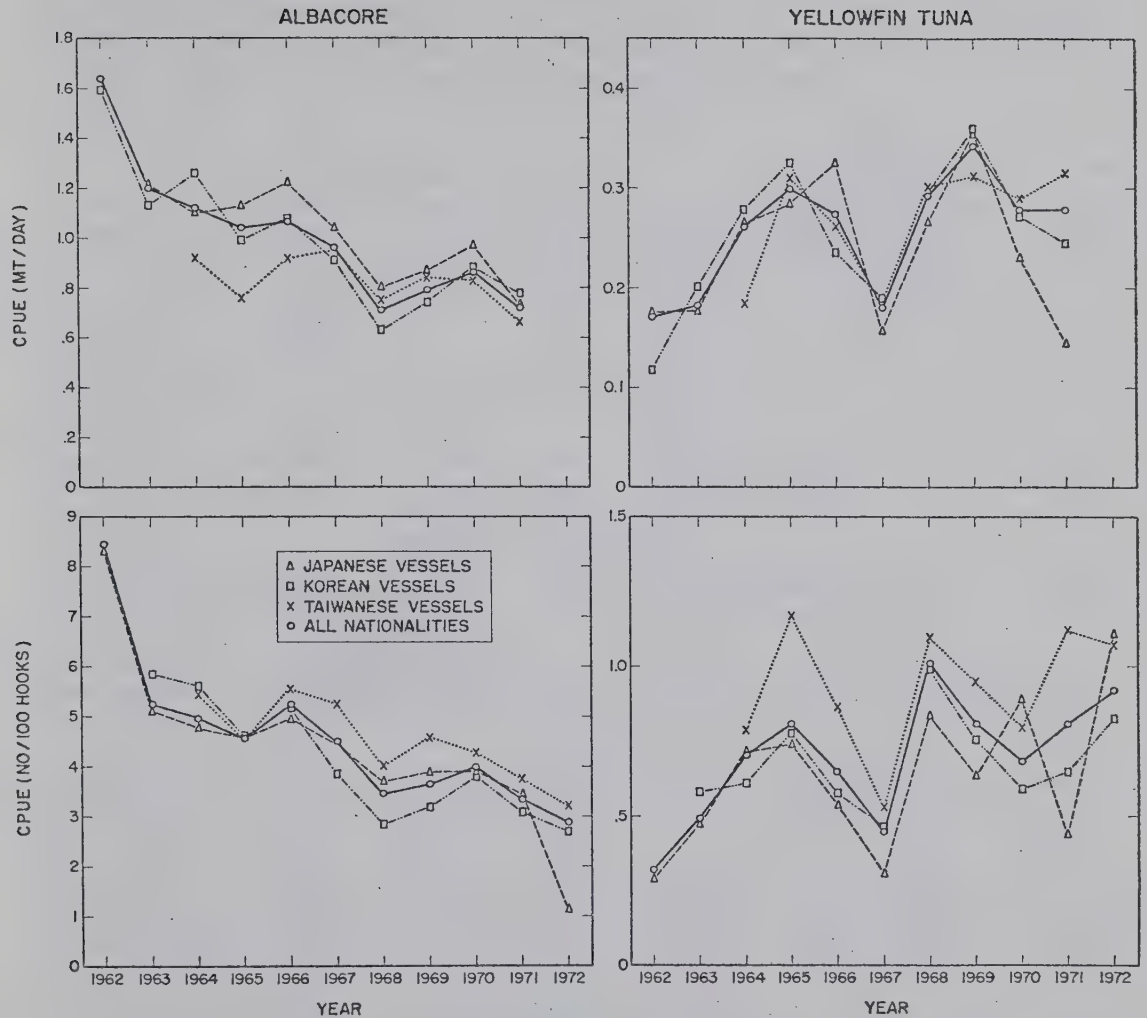


Figure 3.--Temporal trends in catch per unit effort (CPUE) for albacore and yellowfin tuna in the fishery based in American Samoa. No measurement of effort in hooks was obtained for Korea in 1962 even though they were fishing.

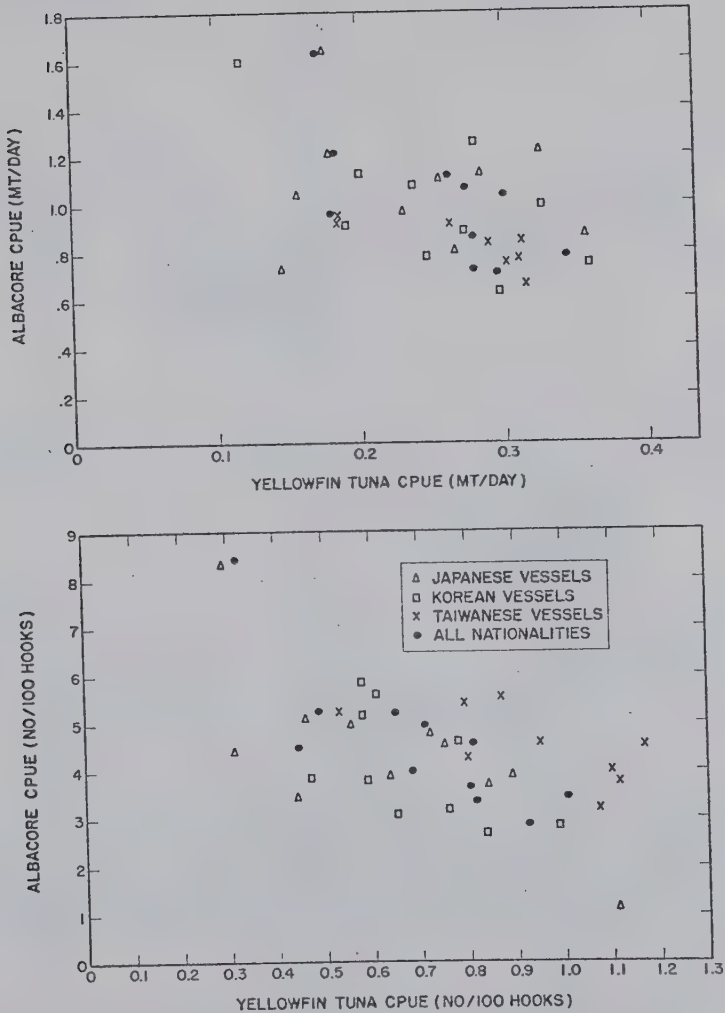


Figure 4.--Comparison of albacore and yellowfin tuna catch per unit effort (CPUE) for the fishery based in American Samoa.

Table 1.--Albacore catch in metric tons for the South Pacific Ocean. Estimates for non-Samoan catches were derived from the number of vessels reported in the Asian Tuna Conference Proceedings. Estimates of CPUE were calculated from all nations pooled in the fishery based in American Samoa.

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		Japan	Korea	Taiwan	Total	MT/10 ³ hooks	MT/day fished	Hooks (x10 ³)	Days
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	Grand total	22,521	3,083	556	26,160			31,035	23,328
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	Grand total	20,389	6,723	1,590	28,702			37,050	27,688
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	Grand total	25,620	12,275	8,604	46,499			53,202	43,624
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	Grand total	17,198	12,893	12,679	42,770			58,302	44,640
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	Grand total	8,569	8,919	11,390	28,878			52,335	40,662
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	Grand total	6,049	12,829	13,881	32,759			56,539	41,567
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	Grand total	6,550	14,448	17,218	38,216			67,176	44,308
1971	Nation	6,437	2,491	8,910	17,838			32,634	24,844
	Am. Samoa	380	11,800	10,014	22,194	0.5466	0.7180	40,604	30,911
	Grand total	6,817	14,291	18,924	40,032			73,238	55,755

¹Includes undetermined nationality.

Southwest Fisheries Center Administrative Report No. 41H, 1974

COUNTRY STATEMENT - U.S.A.

1. FISHERIES ADMINISTRATION

The primary functions of the National Marine Fisheries Service (NMFS) have been assigned to three major units, each headed by an Associate Director who reports to the Director of NMFS. These units are concerned with Resource Research, Resource Utilization, and Resource Management.

Large research vessels of NMFS and other components of the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) were transferred in 1973 into a consolidated fleet operated by the Office of Fleet Operations (OFO) under the National Ocean Survey (NOS).

2. PLANNING

NMFS will devote major effort to the promotion of fish now little-used or discarded, will provide technical assistance in processing, and will materially expand its efforts in foreign and domestic marketing.

Basic planning was completed for the development of an alternative yellow fin tuna management system for the eastern tropical Pacific, a management system for Atlantic tuna stocks, and a global tuna system computer model for quantitatively assessing the impact of management decisions on the world tuna system.

NMFS launched a survey to identify U.S. research projects aimed at the reduction of pollution caused by fishing activities. Information will be sought from wide-ranging fields including those that deal with the studies of harbors, byproduct utilization, and design of fish processing plants.

On October 18, 1972, Congress passed the Federal Water Pollution Control Act Amendments of 1972 (PL 02-500), which affected every seafood processor in the U.S. The intent of PL 02-500 is that by 1983, our waters will be clean enough to protect fish and shellfish and will be suitable for swimming and other recreational uses. By 1985, all harmful discharges into the nation's water will be eliminated.

2.1 MARMAP

The National program called Marine Resources Monitoring, Assessment, and Prediction Program (MARMAP), which was launched in 1970 under the direction of NMFS, continued to make progress in 1973. Samples and data collected by a multiship survey in the winter of 1973 indicated unusual concentrations of larval spotted hake, mullet, herring, weakfish, spot, and croakers along the mid- and south Atlantic coast, suggesting that these species could support expanded fishing operations.

2.2 State-Federal Fisheries Management Program

In 1973, in a positive effort to solve the problems of overcapitalization, economic inefficiencies, and stock depletion, the State of Alaska enacted the Limited Entry Act. Under this act, a State Commercial Fisheries Entry Commission was created and charged with the responsibility for promoting conservation, for maintaining economic health and stability in the various fisheries and for regulating and controlling entry into the commercial fisheries. Limited Entry appears to be an ideal way to control Alaska's salmon fishing, but the policy decisions to determine who will be permitted to fish and who will be denied the right to fish are very difficult.

The Governor of the State of Washington also signed into law the State's first legislation limiting entry into its fisheries. The only practical effect at present, however, is on Washington's salmon fisheries. The bill limits at current levels all salmon gear including troll, purse seine, gill net, and reef net.

3. MARINE RESOURCES

3.1 Resource surveying, experimental and exploratory fishing, location of new fishing grounds

An instrument that is expected to locate commercially important fishery resources has been developed in the U.S. under the sponsorship of two units within NOAA--the NMFS and the Office of Sea Grant. Named RUFAS II (for Remote Underwater Fisheries Assessment System), the instrument is towed behind a research ship, dives on command to look at selected underwater features, and photographs the surrounding scene with video tape and 35 mm film. This second generation robot diver continuously televises its observations to the mother ship, can inspect the sea floor at great depths, and sends warning signals to the shipboard operators when underwater navigational hazards are detected. Diving as deep as 730 m, RUFAS II can ascend at a rate of 0.75 m per second and can be towed at speeds up to 6 knots by a cable more than 1.6 km long.

In 1972, an NMFS-chartered fishing vessel operating out of Honolulu, Hawaii, explored the possibility of developing commercial pole-and-line fisheries for skipjack tuna, Katsuwonus pelamis, in the Marshall Islands and American Samoa. Tuna resources in the Marshall Islands and American Samoa were impressive. Bait was plentiful in the Marshall Islands but scarce in American and Western Samoa. To conduct fishing trials in Samoan waters, the vessel obtained live bait in Fiji. Both tuna and bait were abundant around Fiji.

Large, undeveloped grounds of the little-harvested mollusk, the ocean quahog, was discovered by survey vessels of the Middle Atlantic Coastal Fisheries Center, Sandy Hook, in 1973. Abundance estimates placed the resource in coastal waters from New Jersey to Virginia at about 1.1 million metric tons. Off Long Island, the resource was estimated to be 1.5 million metric tons.

In 1973, the Inter-American Tropical Tuna Commission (IATTC) investigated the relationship between sea-surface temperatures in the spawning areas and skipjack tuna abundance in the fishing areas. The reasoning is that since the

number of skipjack tuna larvae increased with temperature, warm years in the central Pacific spawning areas may result in higher indices of apparent abundance in the fisheries of the eastern Pacific. Correlation between various indices of skipjack tuna abundance and those of sea-surface temperatures and atmospheric pressure one and a half years earlier were significant in 28 out of 31 tests.

3.2 Fisheries biology (including methodology and techniques), studies on age determination, tagging, population dynamics

A technique of counting lamellae which have been laid down daily has been developed to directly age fish. Scientists at the Honolulu Laboratory, Southwest Fisheries Center, have constructed growth models from larval stage to adult for the Hawaiian anchovy, Stolephorus purpureus, and skipjack tuna. Age and growth studies of skipjack tuna from other areas of the Pacific are in progress.

In studies on the population dynamics of the Palauan anchovy, Stolephorus heterolobus, a baitfish used extensively in the fishery for skipjack tuna in Palauan waters, it was determined that total mortality rate for a 19-month period was 6.0 per year. This means that 3 fish out of 1,000 live to be a year old. The average fishing mortality was 3.0 per year. The logistic model indicated a maximum sustainable yield of about 80,000 buckets with an effort of under 2,000 boat-nights. The study concluded that the bait fishery in Palau is currently operating at the optimum level.

Tagging experiments on yellowfin and skipjack tuna continued to receive considerable emphasis in 1973. With fishing effort for these species in the eastern Pacific expanding rapidly 1,000 to 3,000 km offshore, tagging studies concentrated on the extent of mixing among the fish of various inshore and offshore areas.

A number of projects underway at NMFS centers and laboratories dealt with the physiology of economically important marine species. Significant among them were the research at the Honolulu Laboratory, Southwest Fisheries Center, on sensory and other physiological reactions of tunas and tunalike fishes to their physical environment, and an acoustical survey of sockeye salmon in Lake Washington by the Northwest Fisheries Center, Seattle.

To support negotiations and apply effective management practices in international bilateral agreement and commissions and domestic State-Federal programs, NMFS centers prepared annual assessments of the conditions, changes in abundance, and predicted maximal yield levels for important species such as salmon, tuna, shrimp, halibut, cod, crab, flounder, hake, herring, haddock, mackerel, menhaden, and lobster. Special surveys of marine sport fish species by the Northwest Fisheries Center, Seattle, provided information on angling opportunities and fishing techniques for recreational anglers.

Marine mammals programs included studies on population dynamics, age structure, feeding habits, distribution, migration, and interrelationships with other living marine resources. Studies on reducing or possibly eliminating porpoise mortalities in the tuna purse seine fishery were fully augmented. Preliminary tests on a prototype net constructed of different taper and mesh

sizes were started to evaluate its effectiveness in removing porpoises from the seining operations. Concerning fur seals, St. George Island was set aside as a research control area of no harvest.

3.3 Management, laws and regulations, control of pollution

Results of assessments by the Northeast Fisheries Center, Woods Hole, of the total yields available from the fish stocks off New England and mid-Atlantic states indicated serious overfishing. This led to the agreement by all ICNAF member countries to reduce total catch of all species to allow for restoration of the stocks.

In 1973, the Northwest Fisheries Center, Seattle, initiated a program to place observers on Japanese trawlers in the Bering Sea. Data collected through this program will be used for developing an effective management rationale for the heavily exploited North Pacific fish stocks.

Concerning yellowfin tuna, studies at the Southwest Fisheries Center, La Jolla, showed that the Atlantic stocks were in good condition in 1973, but that the fishery was approaching or had attained a plateau. Furthermore, substantial increases in sustainable yield from this species cannot be expected by increasing fishing effort unless there are accompanying changes, such as spatial or temporal distribution of fishing effort, in the fishery.

NMFS environmental research in 1973 involved studies of the estuarine and nearshore ecosystem to establish baseline data to evaluate the environmental impact of manmade and natural alterations. Studies at the Atlantic Estuarine Fisheries Center, Beaufort, involved assessment of species structure, biomass and energetics of the ecosystem; determination of pathways and rates of flow for contaminants, particularly heavy metals, radionuclides, and pesticides; and determination of the effects of various contaminants to which organisms are normally exposed. Studies at the Northwest Fisheries Center (Seattle), and the Southwest Fisheries Center (Tiburon Laboratory) are examining the relationship between oil and aquatic organisms. A chronic exposure facility was completed at the Middle Atlantic Coastal Fisheries Center, Milford, and studies there involved the effects of exposure of marine organisms to sublethal levels of various pollutants.

3.4 Research progress and institutions

The Congressional mandate which created the Sea Grant programs called for development of marine resources for economic and social benefits to the nation and for the education and training of personnel to carry out such development.

Among the accomplishments reported under the Sea Grant program was the new removal system which blasts barnacles from the hulls of ships while at anchor, resulting in savings of time and money. Two engineers from the University of Washington Sea Grant program collaborated with private industry to develop specially designed instruments which determined the shock level for efficient cleaning of a ship's hull. By keeping the explosive blasts within this range, cleaning was accomplished without any damage to the ship's structure.

An informal Tuna Baitfish Workshop, sponsored by the Southwest Fisheries Center, Honolulu, and the University of Hawaii's Sea Grant, was held June 4-6, 1974. Thirty-six papers were contributed to the workshop; 38 persons attended from the U.S., Japan, Papua New Guinea, Gilbert and Ellice Islands, American and Western Samoa, and the U.S. Trust Territory of the Pacific Islands. The workshop opened with a general session followed by concurrent sessions on natural stocks, cultured species, and baitfish transport-baitfish substitute. Recommendations arising from the workshop were based on problems and needs identified during the sessions.

At the Southwest Fisheries Center, Honolulu, attempts are being made to develop the technology needed for transporting live northern anchovy, Engraulis mordax, from California to Hawaii. A surplus 18,900-liter aircraft refueling tank was acquired and converted into a bait transport tank. Several trial shipments have been made with varying success. Development of a practical bait-transport system could help significantly to promote and expand pole-and-line fishing in the Pacific Islands.

4. AQUACULTURE

4.1 Intensive and extensive culture techniques--increase in yields

In 1973, the major emphasis in aquacultural research involved Pacific salmon and penaeid shrimp. Studies at the Northwest Fisheries Center, Seattle, evaluated a saltwater pen-rearing system for Pacific salmon, treatment of saltwater salmonid diseases, experimental feeds, stock development, and breeding. At the Gulf Coastal Fisheries Center, Galveston, studies involved developing a dependable method for maturing female shrimp in captivity, methods for recognizing, preventing, and treating diseases, and methods for intensive culturing of shrimp in a closed system.

Concerning salmon culture, a salmon farm in Wiscasset, Maine, has been using warm water discharged from a power plant to obtain rapid growth. Mortality from the hatch of 100,000 eggs was estimated at 29%. The farm operator expected to harvest 18 MT of pan-sized salmon during the period February to August 1974. The salmon were kept in cages which were confined to a warmwater pen area by a log boom.

Salmon farming technology developed by the Northwest Fisheries Center, Seattle, has accelerated growth of fish for eventual pen harvest (commercial operations) and open range harvest (catch mainly by sport fishermen). Although technology is still in its formative stages, four private salmon farms have been built in Puget Sound. Three of four farms harvested 139 MT of pan-sized salmon in January-March 1974. The fourth farm released 8 MT of pen-reared salmon into south Puget Sound for the benefit of the sport salmon enhancement program. In addition, another firm is in the commercial pilot plant stage and six more are seriously considering investment in salmon farms.

The continuous cycling method for culture of the giant freshwater prawn, Macrobrachium rosenbergii, continued to receive attention in 1972-73. The method, developed by scientists of the Hawaii Division of Fish and Game, was applied in a pilot operation to obtain consistent production. Tests on prawns

reared in the pilot pond showed production of 336 kg per hectare of marketable prawns per month. Studies have also been centered on formulating and testing inexpensive prawn feed.

Warm seawater, discharged from the heat exchangers of a giant steam electric power plant in California, was used to grow oysters. Test crops of eastern oysters, Crassostrea virginica, showed impressive growth rates when cultivated in warm water. Mature marketable sizes may be reached in about a third of the time required under normal conditions.

Cooperative research on catfish breeding continued at various laboratories in 1972-73. The results indicated that the young of hatchery-reared fish generally have lower survival rates than those young whose parents were brought directly from the wild. However, young fish from wild parents apparently do not grow as well in the pond environment as semidomesticated hatchery fingerlings during the first year. Crossbreeding of wild and hatchery stocks improve disease resistance.

4.3 Feeding, feedstuff

Nutrition studies included the analysis of pelagic red crab, Pleuroncodes planipes, to assess its value as a dietary component in salmonid diets. Pelagic red crab, which has a high carotenoid content ranging from 10 to 16 mg per 10 g of whole body weight, is a source of relatively inexpensive carotenoid for pigmenting pen-reared salmonids. Rainbow trouts were highly pigmented when fed diets containing 10%-25% red crab for 2 months. Other studies indicated that fractionation of red crab could produce a dry feed material and a chitinous residue for processing into derivatives such as chitosan.

5. INFRASTRUCTURE

5.1 Harbors

In a waterfront renewal project in Gloucester, Massachusetts, a 6,500 sq m building will be erected on a 2.5 hectare parcel of land. The huge plant will house eight firms and will be the first fresh fish processing center on the eastern seaboard. Included in the planning are finger piers to provide docking for 25-30 dragners. The proposal also calls for a freezer-cold storage facility with a holding capacity of 1,360 MT and 12 plate freezers capable of handling 18 MT of fish per hour.

6. FISH CAPTURE

6.1 New types of gear introduced into commercial fisheries

A promising improvement has been recently developed to further help the porpoise escape from the purse seine. The improvement is a corkline panel, which is a solid strip of vinyl-covered nylon wrapped around the corkline and extending down the side. Its function is to prevent porpoise from being snagged in the corkline by providing a ramp over which they can slide as fishermen herd them out of the net.

A new funnel-shaped bottom trawl that could significantly boost catches by New England fishermen has been developed at the University of Rhode Island. In tests conducted by two NMFS research vessels, the net, called the URI 340, caught more fish than the Yankee 37 trawl now used all along the east coast. The URI 340 is designed so the mouth or door end opens to a larger size than traditional trawls.

7. UTILIZATION

7.1 Improvement in fresh fish handling, distribution, ice supply

A refrigerated seawater (RSW) system, modified by addition of carbon dioxide (CO_2) to the brine, was developed for vessel use and found to be significantly more effective in preserving whole pink shrimp and halibut at sea.

Quality of pen-reared salmon and trout improved significantly when the fish were processed by immersing them immediately after harvest in low temperature water followed by bleeding.

A State-operated seafood control laboratory is planned for the port of New Bedford, Massachusetts. Under the supervision of the Department of Public Health, Food and Drugs Division, the laboratory, staffed by a chemist, bacteriologist, and two inspectors, will be responsible for quality control of all seafood processed in New Bedford. Eventually, it is hoped that the laboratory's services will include other important forms of technical assistance to the Massachusetts fishing industry.

7.2 Product development, new processing methods and equipment

In 1973, after more than 10 years of research, the program to develop methods to process fish into fish protein concentrate (FPC) was terminated and a comprehensive report prepared. Sufficient scientific evidence was presented to the Food and Drug Administration to permit it to remove all packaging restrictions on FPC.

A fishery for sea urchin has developed in southern California. Sea urchins, long considered a pest in California waters because of their overabundance, are prized for their roe, which is eaten in Japan and in many European and South American countries. Rather than destroy sea urchin, the Southwest Fisheries Center, Tiburon Laboratory, promoted the utilization of sea urchin roe and developed a fishery for these invertebrates. At present, the domestic market is firmly established and effort to export large quantities to other countries is continuing.

In shellfish research on underutilized species such as deep-sea red crab, Geryon quinquedens, and Jonah crab, Cancer borealis, NMFS scientists found that the yield of crab meat could be increased by optimizing cooking times, temperatures, and picking technique. In research on squid, an abundant but underutilized species in the U.S., NMFS has developed several mechanical methods of skinning and eviscerating squid and produced acceptable new products.

A technique for extracting protein and industrial chemicals from shellfish processing wastes on a commercially attractive scale was developed in the U.S. in 1973. The two principal shellfish products are chitin and its derivative chitosan. Industry and two government agencies, Sea Grant and the Environmental Protection Agency (EPA), cooperated in this venture. A big market possibility for these two products lies in municipal and industrial waste-water treatment. Chitin and chitosan are also proposed as additives in the paper making process in baby food, in paint emulsions, stomach antacid, textile finishes, shoe polishes, synthetic fibers and as food thickeners.

In 1969, the geoduck, Panope generosa, the beef clam that ranges from Alaska to California was found in great abundance in Puget Sound. Commercial production of these clams became possible after a survey by the State of Washington Department of Fisheries revealed many millions were available in subtidal waters. Divers estimated that there were two or more siphons per 0.1 sq m. A water pump, wash-out nozzle with high water pressure, inserted deep alongside the clam, was approved and used for recovery of the geoduck. The stability of the market for geoduck was due primarily to the group of processors who launched a campaign to educate their markets, and tenderized and packaged their product attractively.

NMFS marketing activities included market development, market intelligence and consumer education. Significant accomplishments of the market research and service program included a major effort to help industry develop new domestic and export markets for mullet and mullet roe. Utilization of mullet has increased in the U.S. and markets for mullet roe have been developed in Japan, Taiwan, and France.

7.3 Research activities and institutions

NMFS conducts microconstituent research programs at the Pacific Fishery Products Technology Center, Seattle, and the College Park Fishery Products Technology Laboratory, College Park. Designed to provide a sound and comprehensive data on the occurrence and significance of microconstituents, the program direction to date has been in heavy metals, other inorganic trace elements, and organic contaminants such as pesticides and PCB's.

In 1973, an extensive survey was initiated to obtain baseline data and to identify possible programs related to 15 inorganic elements in over 200 species from U.S. offshore and coastal waters. The results have shown that fish generally contain low levels of mercury, thus refuting the adverse publicity which implied that all fish are high in mercury. Data collected from these surveys will be handled by a computerized system and the results will be used to (1) assess changes in levels of microconstituents, (2) provide factual scientific evidence on microconstituents, and (3) provide evidence to the Food and Drug Administration on the establishment of guidelines on trace elements.

25th Tuna Conference

HYPOTHETICAL SKIPJACK TUNA HABITAT BASED ON PHYSIOLOGICAL LIMITS

By

Richard A. Barkley¹

SUMMARY

Neill, Gooding and others at the National Marine Fisheries Service Honolulu Laboratory have measured a variety of physiological parameters of skipjack tuna. The factors which most obviously tend to limit the distribution of these fish are: (1) the lower lethal temperature, approximately 14° to 18°C depending upon prior conditioning; (2) the lower lethal dissolved oxygen concentration, 4 to 5 ppm or 2.8 to 3.5 ml/liter; and (3) an upper temperature bound which varies with size and metabolic rate of the fish.

According to Neill, a normally active skipjack tuna, whose metabolic activity requires some 3 mg oxygen/gram/hour, undergoes thermal stress if the ambient water temperature exceeds 35°C for fish smaller than 2 kg, and lesser temperatures for larger fish, such as 20°C for a 12 kg animal. If the water is too warm, skipjack tuna must either reduce their activity, or risk overheating of muscle tissue, because they conserve body heat with marked efficiency.

Skipjack tuna should therefore inhabit waters with oxygen concentration in excess of 3.5 ml/liter, and temperatures between about 18°C and the upper bound appropriate for their size and activity. Throughout the equatorial Pacific Ocean, water in the lower portion

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of this temperature range is deficient in oxygen, and the maximum habitat depth is set by the oxygen requirement. At higher latitudes, the water at the cold limit has enough oxygen, and low temperature is the limiting factor.

Skipjack tuna can exceed their thermal limits for short periods of time, because the time constant (the e-folding response time for a step change in water temperature) for skipjack tuna muscle temperature ranges between 30 minutes and an hour. That is, skipjack tuna can forage for some time in water which is clearly too warm, provided that cool oxygenated water is available immediately below; similarly, they could move into water which is oxygenated but too cold for long-term comfort, as long as there is water overhead in which to warm up afterward.

Clearly the normal habitat of all but the smallest skipjack tuna is the upper thermocline, for most of the year, throughout most of their range. In much of the eastern tropical Pacific, however, water with at least 3.5 ml/liter of oxygen is warmer than medium and large skipjack tuna can tolerate; some 200 km off Mexico's west coast, the minimum temperature of adequately oxygenated water may exceed 26°C, which would stress fish larger than 4 kg. This warm, low oxygen water is found between 10° and 15°N, 105° to 120°W, approximately. Fish which require water cooler than 24°C (those larger than 6.5 kg) should in addition be excluded from coastal waters between Tehuantepec and Cape Corrientes.

The location and extent of these "forbidden" areas probably varies with season, and from year to year, depending upon mixing and advection--and thus upon winds and currents. These variations should be reflected in the geographic distributions of skipjack tuna of various sizes caught off western Mexico.

October 15, 1974

DISTRIBUTION OF SKIPJACK TUNA LARVAE IN THE PACIFIC OCEAN

By

Walter M. Matsumoto¹

ABSTRACT

Skipjack tuna larvae are distributed over an extremely large area of the Pacific Ocean (Figure 1). In the central and western Pacific the larval distribution extends from as far north as lat. 38°N to as far south as 36°S. The distribution narrows eastward so that in the east-central Pacific east of Hawaii the larvae are taken between lat. 10°N and 20°S. In waters closer to central America they are found between lat. 15°N and 2°-3°S. Along the equator the larvae are found almost continuously across the Pacific, except for a break near long. 110°W.

The wide distribution in the west and the narrow distribution in the east is due mostly to the movement of the prevailing ocean currents, which is generally clockwise in the northern and counterclockwise in the southern hemisphere. In the west warm water flowing poleward expands the area suitable for spawning, hence the wide distribution of larvae, and in the east cool water flowing toward the equator constricts the suitable spawning area to a narrow band.

Larval distribution is associated with warm water. Although skipjack tuna larvae have been taken in waters as cool as 22.1°C, the bulk of the successful plankton tows, both in number of larvae taken and in frequency of captures, are made in waters above 26°C.

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Skipjack tuna larvae are also distributed vertically.

The bulk of the larvae are found in the upper 60 m of water, but larvae have been taken at depths between 140 and 200 m. Within the upper 60 m, most of the skipjack tuna larvae are concentrated in the 20- to 30-m depth range during the day, and they migrate to the surface at night.

In equatorial waters (between lat. 20°N and 10°S, west of long. 150°W; between lat. 10°N and 10°S from long. 100° to 150°W; and between lat. 15° and 4°N, east of long. 100°W) where spawning is most prevalent, the larval catch rates (larvae per tow) are high over a wide section of the ocean, from long. 140°W to 160°E. The catch rate drops off sharply to the east and west, and is close to zero in the area between long. 30° and 100°W. The catch rates of adult skipjack tuna (skipjack per 1,000 hooks) obtained by the Japanese tuna longline follows a similar trend. On the basis of these catch results, it can be stated that the heaviest concentration of skipjack tuna spawning, hence of larvae, is centered in the equatorial central Pacific region.

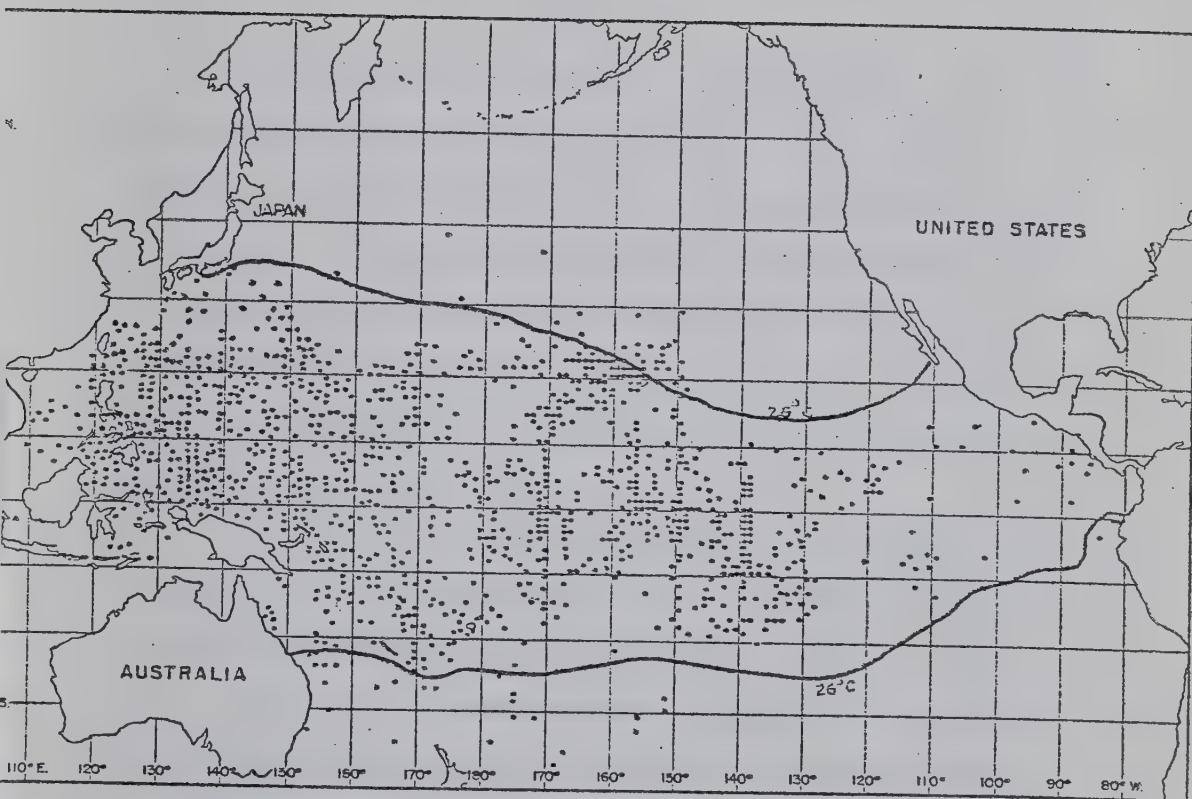


Figure 1.--Capture sites of skipjack tuna larvae, 1949-69. Mean 26° isotherm shown at maximum northern and southern positions.

MOVEMENT OF SKIPJACK TUNA IN THE PACIFIC OCEAN AS DETERMINED
FROM JAPANESE TUNA LONGLINE CATCHES

By

Walter M. Matsumoto¹

ABSTRACT

Catch data of the Japanese tuna longline fishery from 1964 through 1967 were analyzed to determine the distribution, abundance and movement of skipjack tuna in offshore waters of the Pacific Ocean. Although the longline gear is rather inefficient for catching skipjack tuna, its wide usage in the major oceans and in all months of the year makes it especially valuable in assessing the distribution and movement of pelagic species, such as the skipjack tuna, on an oceanwide basis.

The migration paths were determined by (1) computing the catch rates (catch per 1,000 hooks) in each 5° square area fished by quarters for each year, (2) plotting these values and drawing contour lines to isolate cells of high catch rates, (3) connecting the high catch cells in quarterly sequence over the 4-year period, and (4) selecting the most consistent annual paths shown by the shifting of the high catch cells, based on the thesis that the shifts in the high catch cells from one quarter to the next represented movement of skipjack tuna stocks in the ocean.

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The apparent abundance of the skipjack tuna (Figure 1) appeared to coincide with the circulation of the major ocean currents: counterclockwise in the southern hemisphere and clockwise in the northern hemisphere, except in the eastern North Pacific where the current flow is counterclockwise. The proposed movements were consistent with hypotheses proposed by others and with the movements shown by tagging studies in the western and eastern Pacific. They also suggested the possibility that the adults or their progeny could move from one area of the Pacific to the next and from the eastern to the west-central Pacific in both hemispheres.

How well this model of skipjack tuna migration fits the actual conditions in the Pacific can be tested by the more positive means of tag returns. In this respect, the model could be helpful in pointing out those areas where future tagging operations should be concentrated.

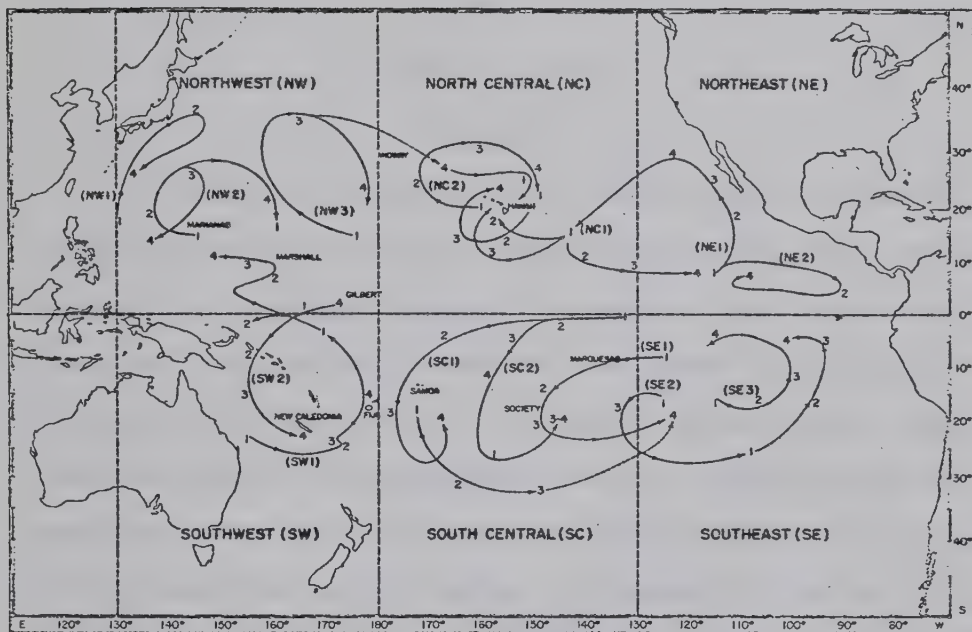


Figure 1.--Assumed movement of skipjack tuna in the Pacific Ocean. The numerals along migratory routes represent quarters and positions of high catch cells of skipjack tuna taken by the Japanese tuna longline fishery.

COMPARISON OF PHYSIOLOGICAL CHARACTERISTICS:
SKIPJACK TUNA (KATSUWONUS PELAMIS) VERSUS OTHER FISHES

By

William H. Neill¹

ABSTRACT

Data from experiments at the Kewalo Research Facility of the Honolulu Laboratory, NMFS, are now sufficient to confirm that the skipjack tuna (Katsuwonus pelamis) is, indeed, a "high performance" fish. This scombrid has metabolic rates that are minimally $0.5 \text{ mg O}_2 \text{ g}^{-1} \text{ hr}^{-1}$ and three to five times those of nonscombrid fishes swimming at the same speed; unlike the relationships found for typical fishes, the routine metabolic rate of skipjack tuna appears nearly independent of both temperature and body weight. Correlated with the skipjack tuna's high metabolic rate and high level of activity are several adaptations for increased oxygen uptake and transport, a high rate of food intake, and relatively low efficiency in conversion of food to flesh (5% to 10% for a 1 kg fish). The high metabolic rate and an efficient vascular apparatus for retarding heat flow from the muscle make the skipjack tuna the warmest of "warm-bodied" fishes on a per unit weight basis; the excess core temperature of skipjack tuna may exceed 6°C kg^{-1} . While such large excess temperatures may increase the efficiency of muscle operation at low ambient temperatures, large fish living in warm waters run the risk of overheating, especially

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during periods of greatest activity. Consideration of this problem suggests size-dependent limits of upper temperature distribution for skipjack tuna.

SIMULATION MODEL FOR PHYSIOLOGY AND DISTRIBUTION
OF TUNALIKE FISHES IN TEMPERATURE GRADIENTS

By

William H. Neill¹ and Andrew E. Dizon¹

ABSTRACT

The long-range goal of the Honolulu Laboratory's program on Life Studies of Tuna and Tunalike Fishes is to generate a predictive model of tuna distribution, abundance, and availability to fisheries. The basis of the model is to be the joint-physiological and behavioral responses of tunas to environmental variables, as determined in part through experimental work with captive fishes. To explore the potential value of such a modeling approach and to provide an objective framework for further experimental work, we have developed a simulation model for the responses of fishes to temperature, a variable of recognized importance in the ecology not only of tunas but also of fishes in general.

The procedure used in constructing the model was 1) to create a hypothetical tunalike fish (based on skipjack tuna) endowed with a simple set of capabilities and responses, all well recognized or reasonably deducible from extant experimental results; 2) "follow" the fish in computer-generated one-dimensional environments with temperature the only variable; and 3) look for consistencies between distributional features of the hypothetical fish and those reported

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for real tunas in real heterothermal environments. Physiological acclimation, accumulation and decay of thermal "doses" leading to lethal-temperature mortality, temperature preference, gradient perception, and basal swimming speed were treated deterministically; perception-contingent increases in swimming speed and the tendency to change swimming direction were modeled stochastically as a biased random walk with constant step-time (10-min., in most simulations).

First runs of the model (without any *a posteriori* manipulation of process functions or input parameters) suggested a number of similarities between the behavior of the model and that of real tunas as observed at sea:

Hypothetical 50 cm long fish weighing 2 kg

- 1) tended to "seek out" and remain within a few degrees of their preferred temperatures in a linear gradient as steep as $1^{\circ}\text{C}/\text{km}$ but to randomly disperse in gradients of 0.1 or $0.01^{\circ}\text{C}/\text{km}$ until encountering temperatures near the upper or lower lethal limits;
- 2) tended to "aggregate" at randomly encountered thermal fronts, regardless of temperature;
- 3) tended to become "trapped" and concentrated in areas of unfavorable temperature under certain conditions of temporal change in the distribution of temperature; similarly, tended to be absent from areas of favorable temperature under certain conditions of temporal change in the distribution of water temperature;

- 4) tended to be distributed within narrower thermal limits than conspecific fish of smaller size.

Next steps in development of the model will involve attempts to experimentally test the validity of proposed process functions and to more accurately parameterize verified functions for tunas. Simultaneously, the model will be optimized and extended for simulation in three-dimensional space characterized by variation in both temperature and oxygen concentration.

25th Tuna Conference

RECENT DEVELOPMENTS IN FISHERIES FOR SKIPJACK TUNA IN THE PACIFIC OCEAN

By

Richard S. Shomura^{1/}

ABSTRACT

Of the several tuna species of commercial importance, the skipjack tuna is the only one that is still underutilized and able to withstand further fishing pressure. Comparing the periods 1960-65 and 1966-72, landings of albacore, bigeye, bluefin, and yellowfin tunas in the Pacific Ocean declined 10, 31, 35, and 15% respectively. The catch of skipjack tuna, on the other hand, increased from 240.0 thousand metric tons to 297.0 thousand metric tons, an increase of more than 46%. Fishing for skipjack tuna has increased rapidly in recent years. Prior to 1960 the important skipjack fisheries were located in the eastern Pacific off the central American coast and in the western Pacific off the Japanese islands. Other minor fisheries were based in Hawaii, Palau (Western Caroline Islands in the Trust Territory of the Pacific Islands) and Tahiti. In the mid-1960's the Japanese began a rapid southward expansion of their skipjack fishing fleet. Boats operating in the southern fishing grounds landed 14.0 thousand metric tons of skipjack in 1964-65. By 1973-74, landings had increased to 84.3 thousand metric tons. Coincident with the expansion of the home-based fleet, Japanese fishing companies entered into a series of joint-venture operations with Governments of several island territories. In Papua New Guinea a joint-venture fishery started in 1970 with a landing of 2.4 thousand metric tons. By 1973 the catch had increased to 28.0 thousand metric tons, and forecasts for 1974 are for an even higher landing.

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Other joint ventures are presently operating in the Solomon Islands, Indonesia, New Bebrides, New Caledonia, and the Philippines.

Nearly all of the increase in skipjack tuna landings in the Pacific has been made using the pole-and-line fishing method. The success of fishing has been clearly related to the successful carrying of large quantities of baitfish over long distances, as in the southern water fishery of the Japanese-based boats, or to a readily available supply of baitfish in the island areas such as Papua New Guinea. Skipjack tuna are known to occur in many other parts of the Pacific islands, but inadequate bait supplies there have precluded the development of new fisheries or the expansion of existing ones. Currently a number of countries, among them the United States and Japan, are conducting field trials to catch skipjack in commercial quantities using purse seine gear.

Early age and growth of skipjack tuna in the central Pacific as indicated by daily growth increments of otoliths.

James H. Uchiyama and Paul Struhsaker

Pannella (1971, 1974) provided circumstantial evidence that the smallest observable growth increments in fish otoliths (sagittae) observed by earlier workers represent daily growth increments. Experiments at the Honolulu Laboratory with the endemic engraulid Stolephorus purpureus provide direct evidence that otoliths grow by daily increments.

Similar structures are apparent in the otoliths of skipjack tuna. Assuming that the increments represent daily growth lamellae, counts for 46 specimens 3.6-75.2 cm FL were plotted as functions of length (Figure 1). The largest specimen had an indicated age of slightly less than 27 months. Two linear growth stanzas are indicated, although the two largest specimens provide some evidence that the growth curve is becoming asymptotic at an age of about 2 years. Skipjack growth was calculated to be 0.78 mm/day between the 6th and 22nd months of life. Central Pacific skipjack reach a calculated length of 42.6 cm at an age of 1 year. A few otoliths from the Papua New Guinea and eastern Pacific indicate slower grow rates of skipjack in these regions (Figure 2). Aging of skipjack by otoliths shows good agreement with previous methods of aging this species (Figure 2). A few otoliths from yellowfin tuna (Figure 3) also show good agreement of other methods of age determination for this species.

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Figure 1.

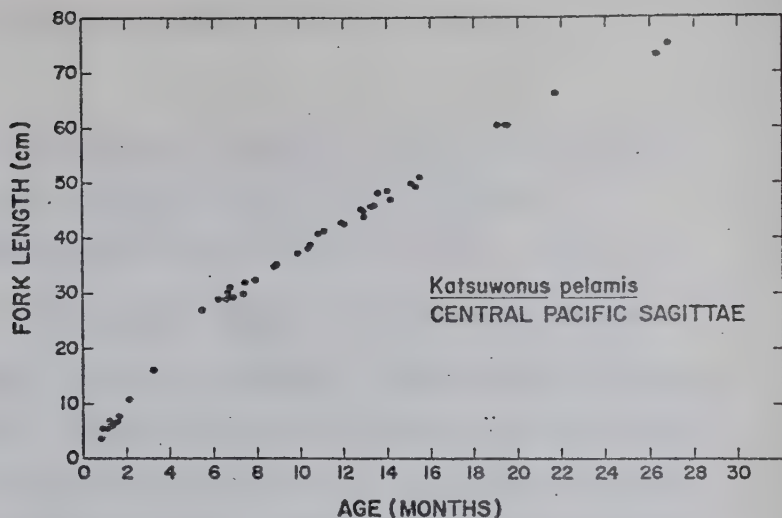


Figure 2.

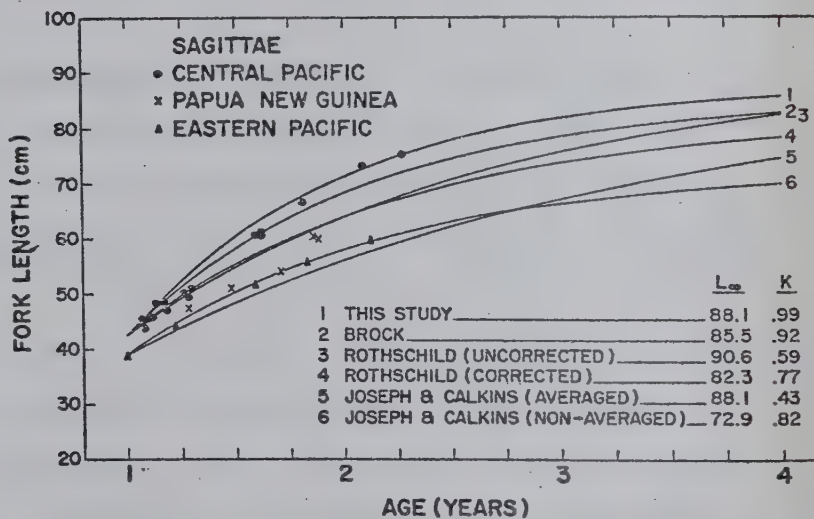
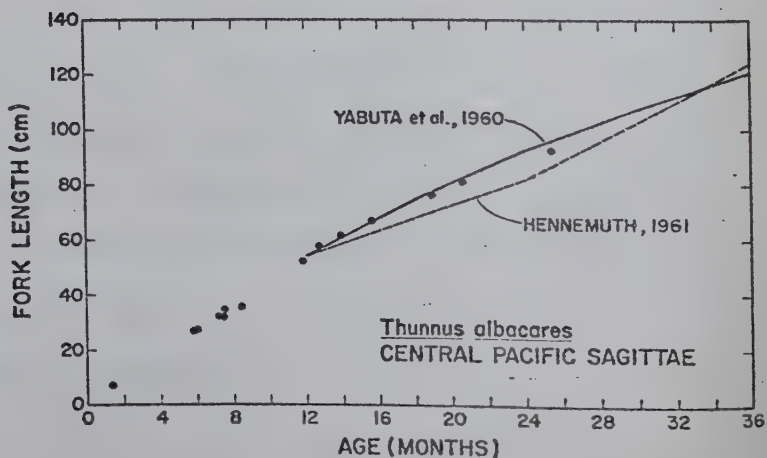


Figure 3.



SOME COMMENTS ON STUDIES OF SKIPJACK TUNA GROWTH

By

Jerry A Wetherall¹

ABSTRACT

It is clear from Paul Struhsaker's presentation that otoliths of skipjack tuna may be used to provide reliable estimates of age. Hence, it should be possible now, using a standard technique and common set of criteria, to construct tables or curves giving size at age for skipjack tuna stocks in different areas of the Pacific and during different time periods.

Curves of apparent growth drawn from the otolith data tend to confirm and validate most estimates produced by other methods, such as modal progressions and tagging, in two areas of the Pacific so far studied. Within any particular stock, the discrepancies between estimates of size at age produced by the different techniques do not seem to be very serious (within the range of observations) in view of the various possible biases associated with each method, differences in time of sampling, etc. However, extrapolations beyond the range of observed lengths may lead to some disagreements. In this connection it should be noted that only in the growth curves of Brock for the Hawaiian skipjack tuna were observations made in the neighborhood of the estimated asymptotic size.

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The central Pacific otolith data so far accumulated indicate essentially linear growth up to about 75 mm. The estimates of von Bertalanffy K and L_{∞} for these data are not yet reliable. Assuming there is an asymptotic phase of growth for skipjack tuna, more observations will be required in the region of L_{∞} before L_{∞} or the growth rate K of the von Bertalanffy model can be determined precisely.

In comparing the growth curves from different areas, the most striking feature is of course the apparent differences in growth rate and maximum size between skipjack tuna taken in the Hawaiian region and skipjack tuna caught in the eastern Pacific and around Papua New Guinea. If these differences in growth are real, there could be a twofold to fourfold difference in yield per recruit at full exploitation between stocks in these areas. Whether the differences are primarily environmentally or genetically based cannot be determined at least until the subpopulation structure of the different stocks is elucidated. This may best be realized by a massive tag-and-recapture program coupled with comparative analyses of inheritable protein systems in the blood and other tissues.

In addition to clarifying the question of stock structure, tagging could shed some light on possible biases in the growth curves in all areas of the Pacific arising from such processes as size-specific migration. It has been hypothesized, for example, that the differences in growth rate between skipjack tuna caught in Hawaii and those taken in the eastern Pacific may be due in part to the longer residence time of slower growing skipjack tuna in the eastern Pacific and hence an overrepresentation of slower growing fish in the samples from this region.

DRAFT FOR COMMENT

A PROPOSAL FOR THE DEVELOPMENT OF POLE-AND-LINE
FISHERIES FOR SKIPJACK TUNA
IN THE CENTRAL AND WESTERN PACIFIC

December 1974

Prepared by Staff, Honolulu Laboratory, for Pacific Islands
Development Commission.

DEVELOPMENT OF POLE-AND-LINE FISHERIES FOR SKIPJACK TUNA
IN THE CENTRAL AND WESTERN PACIFIC

Summary

What: Define the bait supply problem for pole-and-line skipjack tuna fishing for island governments of concern to the United States and evaluate several of the more promising bait fishing systems, including development of local fisheries using naturally occurring baitfish stocks and culture of suitable baitfish species.

Plan and develop bait fishery modules suitable for the various island governments in the central and western Pacific which should provide immediate economic benefits to the people of the Pacific islands.

Final Results

If the various problems are overcome and the economic situation proves acceptable, the long-range results to be expected are:

- Decrease in dependence on foreign sources for tuna for U.S. canners.
- Increase in economic viability of the central and western Pacific peoples through development of a new or expanded industry.

Program Details

Where: • The major portions of the work will be centered at locations best suited for the various activities.

When: • Portions of the program could start in January 1975.
The first phase should be completed at the end of 1975.

How much: The total cost of the 3-year program, if fully supported is estimated at \$1.1 million.

DEVELOPMENT OF SKIPJACK TUNA FISHERIES
IN THE CENTRAL AND WESTERN PACIFIC

Background

A great deal of information on the fishery resources in the central, south, and western Pacific, particularly on tuna and tuna-baitfish, has been obtained during the past 25 years (Appendix 1-5). Thus, an excellent base of data is now available for the development of commercial operations. In recognition of this, recent efforts have been made by the Pacific Islands Development Commission (PIDC), the United States tuna industry and the United States government separately and in concert to launch an expanded program for tuna fisheries development in the area (Figure 1).

In July 1972, the Marine Resources and Development Committee (MRDC) of PIDC proposed a plan for the development of tuna resources in the central, south, and western Pacific. This plan was prepared in anticipation of passage of P. L. 92-444 (H. R. 12207) on September 29, 1972, "The Central and Western Pacific Fisheries Development Act." The bill authorizes the expenditure of \$3 million over a 3-year period (July 1, 1972-June 30, 1975).

Because of the increasing importance of developing a substantial skipjack tuna fishery in this area of the Pacific, the National Marine Fisheries Service (NMFS) examined the PIDC plan and reviewed other available information on the resources and the fisheries. Following this review a draft document entitled, "Central and Western Pacific

Tuna Fishery Development Program" was prepared by NMFS Southwest Fisheries Center (SWFC). Subsequently, another document entitled, "A Cooperative Program for Development of the Tuna Resources of the Central, South, and Western Pacific," which is a synthesis of the PIDC and NMFS plans, was jointly prepared by NMFS and tuna industry representatives for approval of the several interested parties.

In October 1974, the United States government, under authority of P. L. 92-444, released funds to initiate work outlined in the NMFS-PIDC document. The United States tuna industry and the PIDC governments also contributed funds toward this work. Briefly, the main thrust of the program is to develop purse seine fishing techniques for skipjack tuna in the central and western Pacific.

The Problem

The island regions and elements of the tuna industry have common interests in fishery development, but they also have some quite different objectives. Each would agree that there is a need to establish historical fishing rights in the vast area of the central and western Pacific in order to assure access to the tuna and other high-seas fishery resources and a voice in their management. Beyond that, however, the island interests look to the harvest of the resources to contribute to the employment of their people and their overall economic development and the United States industry looks to the region for an additional supply of raw material. Thus, although the PIDC

governments will accrue economic benefits by the implementation of the NMFS-PIDC plan, which emphasizes work on developing techniques to purse seine for skipjack tuna in the waters of the central and western Pacific, the economic gain to the peoples of the Pacific would be greater if the fishery development work emphasized other aspects of the problem. The development of live-bait, pole-and-line fisheries presumably would involve greater participation by the peoples of the Pacific and therefore make a greater contribution to the overall economic development of the area. However, the development of a pole-and-line fishery requires first a need to resolve the various problems with baitfish which to date have constrained establishment of new fisheries for skipjack tuna or the enhancement of existing fisheries in many areas of the Pacific.

PROPOSED TASK AND ACTIVITIES FOR THE DEVELOPMENT OF SKIPJACK TUNA
FISHERIES IN THE CENTRAL AND WESTERN PACIFIC

Briefly summarizing the situation detailed earlier, it was pointed out that the direction of the work initiated under P. L. 92-444 would primarily benefit elements of the United States tuna industry although some benefits will also accrue to the PIDC governments. A program that would be more responsive to the needs of the peoples of the Pacific islands would be a program for the development of live-bait, pole-and-line skipjack tuna fisheries. Benefit will also accrue to the United States tuna industry from this program in that, if successful, this program would provide more raw material for the tuna canners. However, it was also pointed out that one of the important constraints on the development of new skipjack tuna fisheries in the Pacific has been the various problems with baitfish.

It is proposed, therefore, that a concerted effort be made to resolve the various problems with baitfish that have constrained establishment of new fisheries for skipjack tuna or the enhancement of existing fisheries in the Pacific. Furthermore, as advances are made toward the solution of these problems, assistance would be provided the various island groups in developing skipjack tuna fisheries by the application of the knowledge gained. An activity network for the program is shown in Figure 2.

Task. Development of live-bait, pole-and-line fisheries for skipjack tuna in the central and western Pacific.

Problems associated with baitfish have impeded the development of pole-and-line fisheries for skipjack tuna in several different ways. First is the scarcity or lack of suitable baitfish species. Examples of this situation are American Samoa and the Line Islands. Another problem is that in areas with naturally occurring baitfish, the supply has been erratic, thus contributing to a less than maximal development of a skipjack tuna fishery. Hawaii is a prime example of this situation. Another problem related to naturally occurring baitfish is the high mortality associated with handling, especially with some of the more delicate species.

A preliminary evaluation of the baitfish problem indicated that the transport of baitfish from areas of high abundance, e.g., California and Central America, to areas of high skipjack tuna density-low baitfish availability, e.g., Hawaii, French Polynesia, American Samoa, may be a practical and effective method to solve the supply problem (Appendix 6). Work on this project to determine the feasibility of a California to Hawaii system is now underway at the Honolulu Laboratory. Answers to the question of whether it would be feasible to transport the northern anchovy, Engraulis mordax, from California to Hawaii on a commercial scale should be forthcoming by early 1975. If the answers are positive the plans are to work closely with the tuna industry in Hawaii to launch a full-scale commercial baitfish transport operation.

Other possible solutions to the baitfish problem were explored at a baitfish workshop sponsored by the SWFC and Sea Grant (UH) held in Honolulu in June 1974 (Appendix 7-11). The workshop was planned so that guidelines could be obtained as to the optimal strategy to follow in attacking the baitfish problem, especially as it relates to skipjack tuna fishing activities in the Pacific.

Also, in an earlier effort to plan a draft program for tuna development in the central and western Pacific and to delineate the possible role of NMFS in the overall program, it was realized that what was needed was a framework for systematically analyzing the fishery development prospects--area by area. This modular approach allows the identification of each of the necessary factors for tuna fisheries development (e.g., resources, bait supply, socio-economic situation, etc.). The plan for each module will define the status of each of the factors and the necessary action required to remove any constraints limiting development.

In view of the foregoing the study area of this task, then, should include various aspects of the baitfish problem such as supply, condition and alternate methods to augment the natural bait supply. As advances are made in the baitfish program activities will be initiated in the development of pole-and-line fisheries. The following provides a list of the possible activities covered by this task and a brief description of each activity.

	<u>Title</u>	<u>Duration</u>	<u>Estimated man-months</u>
Bait fishery development			
1.	Bait surveys	16	28
2.	Assessment of potential baitfishes	12	24
3.	Pilot bait culture facility	12	24
4.	Bait substitutes	9	9
5.	Optimal fishing strategy	9	-
6.	Design bait fishing module and infrastructure	9	9
7.	Management of baitfishes	9	9
8.	Extension service	Continuing	
9.	Fishery liaison	Continuing	
10.	Literature search	6	6

Activity 1. Conduct field surveys to determine occurrence of new potential baitfishes.

This activity should include the preparation of a document showing all previous bait survey work in the central and western Pacific. This project will seek to assist the various administrators of the region in planning and conducting bait surveys to seek out new potential baitfishes.

Activity 2. Assessment of cultured species as potential baitfishes

One of the solutions to the baitfish problem is to devise a system to provide cultured baitfish for skipjack tuna fisheries. For various reasons, e.g., fishermen acceptance of cultured baitfish, past attempts at bait culture have not been very successful. To increase the chances of success, all aspects of baitfish culture should be examined. A number of subactivities are described below.

Subactivity a.--Conduct acceptability field trials using threadfin shad, Dorosoma petenense, in the Hawaiian pole-and-line fishery for skipjack tuna.

The threadfin shad is one of the most promising freshwater fish species tried as baitfish for skipjack tuna to date. The species is fecund, has many of the attributes of a good baitfish in terms of color, size and swimming behavior, is able to tolerate both fresh and

salt water, and is relatively hardy. Limited trials by NMFS research vessels have demonstrated that the threadfin shad can be used effectively for catching skipjack tuna. Unfortunately, a 1-month trial of threadfin shad on a commercial Hawaiian sampan provided results that were inconclusive. The lack of a notable measure of success has been partly attributed to nonfishing related problems encountered by the vessel operators.

Before proceeding with work on the culture aspects of threadfin shad, intensive field acceptability trials should be carried out using threadfin shad taken from wild stocks in Wahiawa Reservoir. The proposed project is to have available to the Hawaiian skipjack tuna vessels an adequate supply of threadfin shad for an extended period. These shad should be made available at no cost to the fishermen. In return for the baitfish, the vessel will be required to provide data on catch and effort. These field trials should be conducted under conditions closely approximating actual commercial pole-and-line fishing operations. Adequate numbers of fishing trials should be repeated so that conclusive answers can be obtained on the acceptability of threadfin shad.

In the event the fishermen find that threadfin shad is acceptable as a baitfish and this is conclusively demonstrated, the plan is to initiate studies for the intensive culture of threadfin shad and to examine the economics of such a culture system.

Subactivity b.--Conduct field trials using golden shiners,

Notemigonus crysoleucas, in the Hawaiian fishery.

This subactivity is proposed as an alternative project, should Subactivity a fail. Some preliminary work with golden shiners have been done by Pacific Aquaculture Corporation (PAC) on the island of Maui under contract with NMFS. The preliminary work suggested that golden shiners were effective for chumming skipjack tuna. However, more field work is needed to conclusively determine the acceptability and effectiveness of golden shiners. The Maui bait holding facilities may be available for this work at nominal cost.

The principal disadvantage of using shiners as a baitfish for skipjack tuna is that the species cannot be acclimatized to sea water. While a relatively inexpensive closed freshwater recirculating system may be devised for short-term application on a skipjack tuna boat, it is unlikely that the golden shiners can be carried on extended fishing trips, e.g., 3-4 weeks.

In conducting field trials, care should be taken that the trials are carried out by fishermen who are not biased against the use of new bait species. Some of the past experiences of NMFS have indicated that part of the failures of species used experimentally as bait can be attributed not to the shortcomings of the baitfish but to the "negative" outlook of the fishermen towards the baitfish.

Subactivity c.--Conduct extensive field trials using the sharpnose mollies, Poecilia sphenops, in the American Samoa area.

Skipjack tuna are reported to occur in commercial quantities in waters around American Samoa. The major handicap in developing a commercial pole-and-line fishery for skipjack tuna is that there is a virtual lack of suitable baitfish in waters around American Samoa. The options available to American Samoa in culturing baitfishes are limited since a number of species considered for use in Hawaiian waters cannot be reared in American Samoa; e.g., the ambient water temperatures encountered in American Samoa probably are too high for successful propagation of the threadfin shad. The lack of large reservoirs also makes the possibility of establishing wild stocks of threadfin shad improbable.

Mollies have been tried on several occasions in American Samoa with success. The outlook for the use of this species on a commercial scale appears promising. It is believed that modifications of fishing gear used and the fishing operations will increase the successful use of this baitfish.

The Government of American Samoa is currently conducting a program to culture an adequate supply of sharpnose mollies for subsequent field trials. As of this date, it appears that the culture program will require a substantial increase in personnel and funding to reach a stage where adequate supplies of mollies can be cultured for the field trials.

Activity 3. Pilot bait culture facility.

As the conclusive effectiveness of new potential baitfishes are experimentally determined, studies should be conducted on the economics and biology of their culture on a commercial scale. For species that are determined to be economically and biologically amenable to culture, pilot plant production experiments on a commercial scale should be initiated.

Activity 4. Bait substitutes.

The existing literature on bait substitute work will be compiled and evaluated. Using this as a base new possibilities will be explored in the use of artificial bait and other bait substitutes for skipjack tuna pole-and-line fishing.

Activity 5. Development of an optimal fishing strategy for the Hawaiian pole-and-line fishery for skipjack tuna.

Presently NMFS is conducting trials to determine the feasibility of economically transporting the northern anchovy from California to Hawaii as a means of solving the baitfish problem. NMFS is also planning to test in 1975 the Japanese automatic pole-and-line device on a Hawaiian sampan to determine its feasibility in catching skipjack tuna in tropical waters. Assuming some success in these two projects, it is feasible that a package could be developed which would incorporate

the disparate parts into a single system. Any measure of success would be a substantial economic gain.

A pilot study could be conducted during 1975 by incorporating the system on the Hawaiian skipjack tuna vessel, the Anela. The circumstances are ideal for the Anela.

The plan would be to have the Anela reduce its crew by 50% (5 men?) and develop a system to provide a continuous supply of northern anchovy to the Anela. If successful the Anela should demonstrate a substantial economic gain; the gain to be achieved by (a) a substantial increase in fishing effort due to eliminating the baiting operations and (2) an increase in profits by virtue of crew reduction (assuming no reduction in catch/effort) and a reduction in operating expenses, e.g., food, and elimination of running time for baiting.

Activity 6. Design bait fishery module and infrastructure.

In many areas where skipjack tuna fisheries do not currently exist and employment is low, the administration prefers development of a local fishery using local people. Because it is less capital-intensive, the operation of a pole-and-line fishery is more suitable than a purse seine fishery. This project will seek to assist the various administrators of the region in developing a suitable localized fishery.

Activity 7. Management of baitfishes.

This study will involve a continuing assessment of the status of the populations of naturally occurring baitfishes in the central and western Pacific. Aspects of the study should include investigations into the biology and behavior of established baitfishes to determine proper handling techniques to reduce mortality.

Activity 8. Extension service.

Although new baitfishes which are experimentally determined to be effective may be found, there will be a problem of their acceptance by the commercial fishermen. A continuous program is needed to work with the fishermen to inform them of the advantages and benefits of using new baitfishes and to keep them informed of other advances made in gear technology.

Activity 9. Fishery liaison work.

The recent interest in developing the skipjack tuna resources of the Pacific region has resulted in rapid shifts in the views for planning and implementing fisheries in the area. A conscious effort is needed to keep up with these developments.

Activity 10. Literature search and evaluation of skipjack tuna fishery data.

Existing foreign and domestic tuna fishery information and statistics along with reports of past tuna exploration and oceanography will be compiled and evaluated to determine promising areas for exploration. The study will concentrate on providing accurate assessments of the variation and average levels of school size, frequency of schools encountered and size of fish.

ESTIMATED COSTS
(In thousands of dollars)

Activity 1

Supervisor (GS-11 equivalent, 16 months)	23.4	
Technician (GS-3 equivalent, 16 months)	10.2	
Vessel (260 days @ \$1,800/day)	<u>468.0</u>	
		501.6

Activity 2

Subactivity a

Supervisor (GS-11 equivalent, 6 months)	8.8	
Technician (GS-3 equivalent, 6 months)	3.8	
Labor, collecting shad (8 men, 80 days)	13.7	
Transport (borrow NMFS tank trailer), gas, driver	5.0	
Purchase and install 6 swimming pools	10.2	
Land rental	0.2	
Fish food	0.3	
Pumps	<u>18.0</u>	
		60.0

Subactivity b

Project supervisor (GS-11 equivalent, 6 months)	8.8	
Technician (GS-4, 6 months)	4.3	
Purchase of 400 buckets of golden shiners	4.6	
Freighting golden shiners to Honolulu	0.6	
Transport golden shiners Honolulu-Maui		
(use NMFS tanker trailer, Young Bros. tug)	0.6	

Holding facility Maui (lease)	1.2	
Fresh water, electricity, pumps	3.6	
Fish food	0.1	
Miscellaneous	0.3	
Field observers (2 observers, GS-9 equivalent, 3 months)	<u>7.4</u>	31.5
Subactivity c		
Labor	13.5	
Build brood and holding facility	30.0	
Fish food	<u>0.2</u>	43.7
Activity 3		
Supervisor (GS-11 equivalent, 12 months)	17.5	
Technician (GS-3 equivalent, 12 months)	7.7	
Construction and equipment	70.0	
Operation	<u>16.0</u>	111.2
Activity 4		
Investigator (GS-11 equivalent, 9 months)		13.2
Activity 5		
Purchase and install automatic pole and line	25.0	
Bait transport (16 trips)	28.7	
Holding facility in Long Beach (6 holding tanks)	40.2	
Operating cost of holding facility (9 months)	40.0	

Baitfish purchase	6.4	
Holding facility in Honolulu (2 holding tanks)	6.7	
Operating cost of holding facility (9 months)	<u>15.0</u>	162.0
Activity 6		
Investigator (GS-2 equivalent, 10 months)		17.4
Activity 7		
Supervisor (GS-12 equivalent, 9 months)	15.7	
Technician (GS-3 equivalent, 9 months)	<u>5.8</u>	21.5
Activity 8		
Investigator (GS-11 equivalent, 3 months/year, 3 years)		13.2
Activity 9		
Investigator (GS-11 equivalent, 3 months/year, 3 years)		13.2
Activity 10		
Investigator (GS-11 equivalent, 6 months)	<u>8.8</u>	
Subtotal		997.3
Overhead (10%)	<u>99.7</u>	
Total		1,097.0

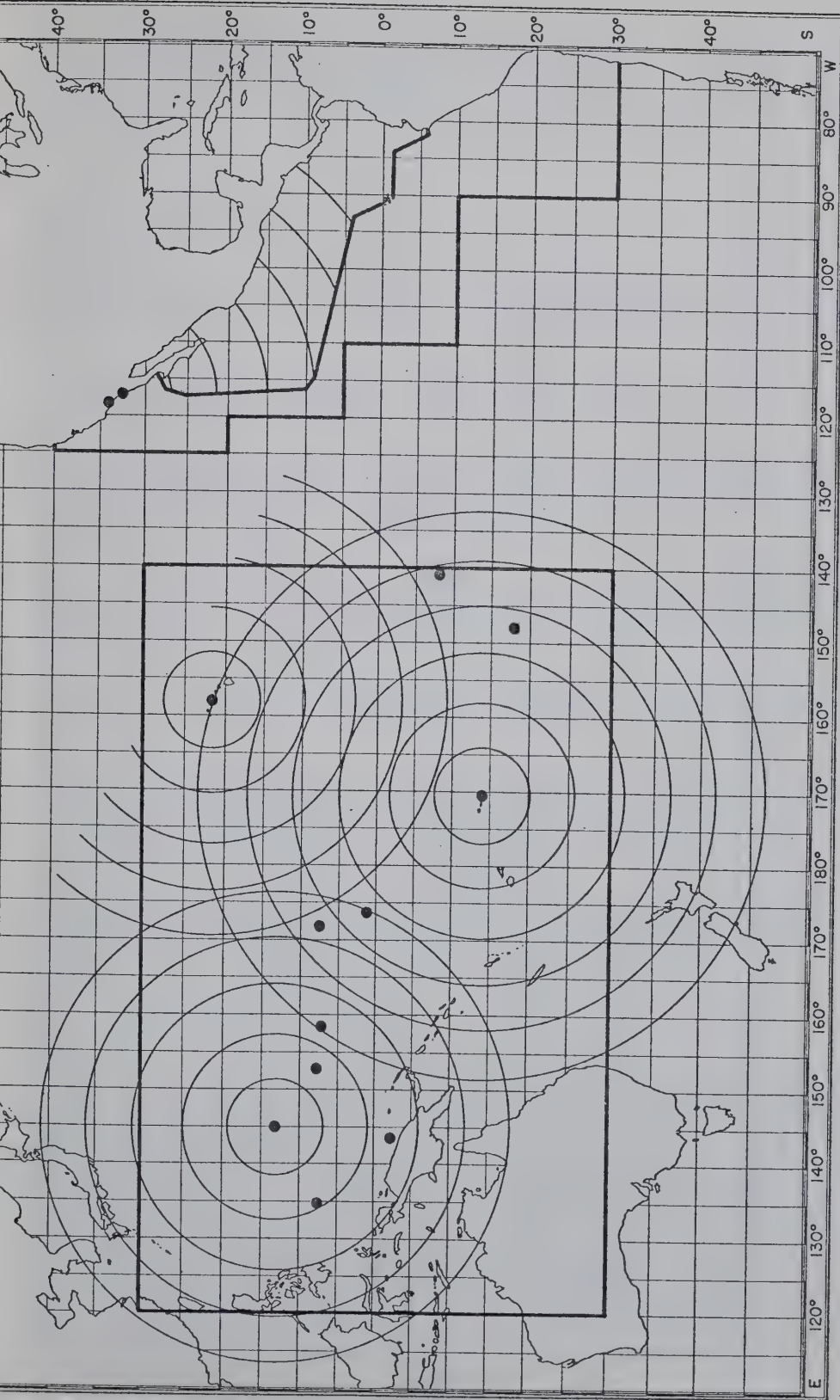


Figure 1.--Area of proposed skipjack tuna fishery development work.

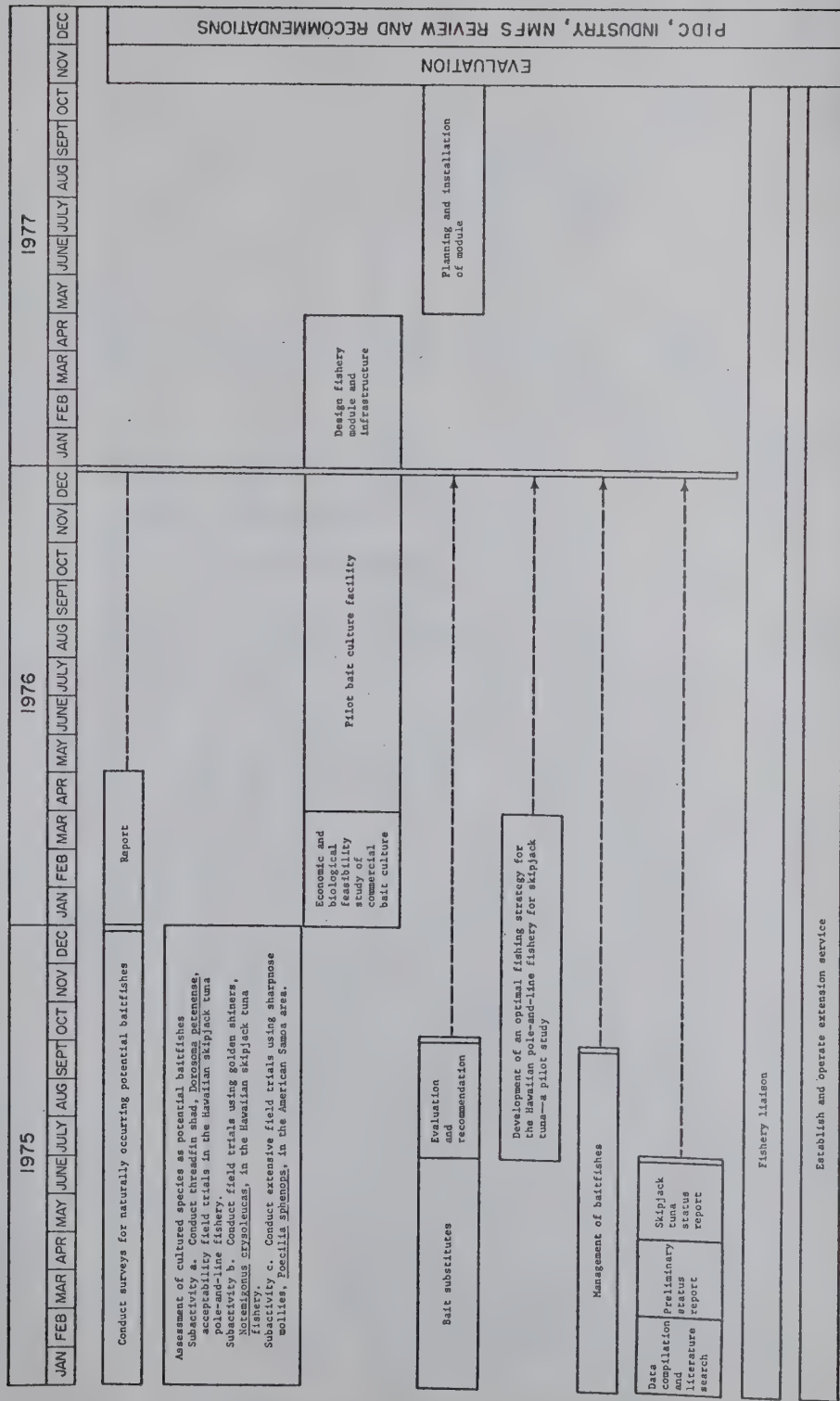


Figure 2.--Suggested activity network for the development of live-bait, pole-and-line fisheries for skipjack tuna in the central and western Pacific Ocean.

APPENDIX 1

SITUATION AND BACKGROUND OF THE TUNA FISHERY DEVELOPMENT PROBLEM IN THE CENTRAL AND WESTERN PACIFIC AREA

1. Situation and background

Although the tuna industry is one of the few U.S. fisheries in good economic health (value \$641 million) several major and inter-related problems are posed to threaten this viability. Briefly, these problems can be summarized as follows:

- The demand for tuna exceeds the present supply causing rising costs for raw and processed products both imported and domestic.
- The world supplies of tuna except for skipjack are already heavily exploited limiting the choices of further expansion to the skipjack resources of the western, central Pacific and Indian Oceans.
- The present international situation fosters increases in the number of boats entering already exploited fisheries causing an increase in costs and an overall decrease in productivity.
- Foreign competition for remaining future supplies of skipjack is building rapidly.
- Technical problems in gear design fishing techniques and in location of commercial concentrations must be overcome before large increases in the skipjack landings from purse seiners can be expected.

A more detailed accounting of the particular situation and problems within each of the broad categories is given in the following. These are summarized from previous reports and discussions with the industry (Appendix 2).

1.1 The demand-supply problem

World and U.S. consumption of tuna is increasing at a rate of about 3.6% per year over the years. However, in 1972 the U.S. consumption increased by more than 25%. This demand has given rise to the development of fisheries (expansion of effort) on almost every major tuna resource in the world. These existing fisheries are either at or near their maximum production with the exception of the skipjack fisheries in the Pacific and Indian Oceans. The limited supply, combined with rising demand especially for skipjack and competing markets, has led to increasing costs for the raw material and the canned products. As an example of these rising costs, during recent years the price paid per ton of skipjack to U.S. fishermen has risen from a low of \$265 in 1969 to a high of \$447 in 1973. Prices of imported skipjack delivered to the California tuna plants during the same period have risen from \$288 to \$610 per ton.

1.1.1 Resource availability

Tuna are a world-wide resource with a total catch of 1.1 million metric tons in 1971. Five species--yellowfin, albacore, bigeye, bluefin, and skipjack--comprise a major portion of the catch taken between 40°N and 40°S latitude. Skipjack tuna are the only tuna resource which is underdeveloped, and scientists estimate that world skipjack production can be significantly increased. It is anticipated that exploration and fishing industry intensity for skipjack will increase substantially by both foreign and U.S. fishing boats.

The central and western Pacific Ocean appears to have a large stock of underutilized skipjack tuna, estimates of increased yield in the range from 100,000 to 1 million metric tons. This untapped resource lies in an area of 11 million square miles, with numerous islands and atolls. The resource is presently not utilized by U.S. fisheries because they do not know how to effectively harvest mid-oceanic skipjack. Specifically, they do not know areas of commercial concentrations and whether it can be harvested with purse seines or live-bait. Purse seining by U.S. vessels in this area have resulted in unsuccessful trips probably because of the fast-moving nature of the schools, clear water, deep thermocline, behavior and size of the schools. Live-bait fishing by U.S. vessels have indicated the potential of this technique but also indicated the lack of adequate bait supplies in certain areas and identified the need to determine the profitability of U.S.-type vessels in the central and western Pacific.

1.2 Capital investment-productivity problem

The present situation regarding international regulations does not limit the amount of fishing effort in any international fishery except by way of total catch quotas. In the absence of allocations among countries it does not behoove any entity to limit the amount of fishing effort unilaterally--competition from other units, e.g., companies or other countries would ensure that those that did limit their effort would receive a smaller and smaller fraction of the total catch. In this climate, the number of boats entering profitable fisheries continues to increase creating a situation whereby more and more boats catch the same total amount of fish during a shorter and shorter season. Naturally this creates a problem in which capital is expended without gaining significant increases in productivity.

Current means of regulated catch by the IATTC in the Commission's yellowfin regulatory area (CYRA) encourages new high-speed capacity to take maximum advantage of the increasing short yellowfin seasons. The U.S. capacity in terms of thousands of metric tons of vessel capacity has increased from 41,000 to 85,000 from 1969 to 1972, a 110% increase. Since the current U.S. yellowfin catch is not expected to exceed 160,000 tons and takes less than 3 months to reach, the average vessel makes less than two trips for yellowfin into the convention area. It is anticipated that the U.S. fleet will increase significantly in the next several years.

The problem of the industry is to maintain the existing capital and use future capital expenditures more efficiently by increasing the supply or by changing the situation that mandates increases in effort or both.

1.3 The problems of increasing supply from the Pacific Ocean

The problems facing the U. S. tuna industry in increasing its supply of skipjack from the central and western Pacific fall into three main categories:

1. Technological problems of gear design, fishing strategies, and location of commercial concentrations.
2. Foreign competition, gaining exclusive long-term advantages in the Pacific.
3. Political and institutional barriers.

1.3.1 Technological problems

The expansion of the U. S. tuna industry into the Pacific tuna fishery will depend on the solution of five main technological problems:

1. The design of a purse seine net and development of fishing strategies and tactics that will be successful in the western and central Pacific waters.
2. The obtaining of a bait supply to support an expanded baitfish operation.
3. The development of a unique or hybrid system that would use, for example, bait and purse seines.
4. General information on the location of commercial concentrations of skipjack tuna.
5. A cost-profit profile of a fishery venture in the central and western Pacific Ocean.

1.3.2 Foreign competition

The Japanese especially are moving to increase their supply of skipjack from the western Pacific. Although the Japanese landings of skipjack in recent years have exceeded 200,000 metric tons, maximum utilization of tuna resources near the home islands and increased demand have indicated that Japan will continue to expand its skipjack fleet in the central and western Pacific Ocean. A recent paper by A. Suda (1972) of the Japan Fishing Agency concludes that the Japanese future skipjack fishery. . . "must be considered in terms of greatly expanded fishing grounds." It is anticipated that Korea and Taiwan will also be attempting to exploit the underdeveloped surface tuna resources of this area.

Japanese fishing companies are expanding into this area by establishing joint ventures with various island governments which in some cases give control of the fishing to the government after a period of 5 years. Presumably the Japanese have long-term agreements (at option ?) to continue to receive the fish after the 5-year period. Another recent development is the legislation passed by the Congress of Micronesia which allows foreign vessels to purchase supplies and bait. At this date they are no longer prevented by law from establishing arrangements to obtain supplies and provision in the Trust Territory. The enactment of this law facilitates the expansion of foreign fishing fleet in Trust Territory waters. Nevertheless the U.S. has a most-favored nation status with the Trust Territory and therefore presumably still has a distinct advantage over foreign competitors in building local fisheries or fishery facilities. The Japanese are now taking about 50,000 metric tons of mostly skipjack in the Trust Territory area with bait boats. In addition, the Japanese have two purse seiners fishing off New Guinea with some success for yellowfin during October and November.

1.3.3 Political and institutional problems

Any future U.S. tuna fishery expansion in the Pacific will have to contend with the political and institutional considerations of PIDC, State of Hawaii, factions of the tuna industry, the U.S. Departments of Commerce, Interior and State, as well as foreign entities. For instance, it is generally thought that the Trust Territory would prefer to see a fishery development that gave maximum use of the islands' manpower and shoreside facilities while others may prefer a situation that depended least on the future political status of the islands.

1.3.4 The industry

Some of the institutional problems facing the U.S. industry concern the industry itself. Even though there is a major problem of supply facing the U.S. tuna industry, it is difficult for individual entities to try to find solutions unilaterally, such as, for example, exploration in new areas. On the other hand, considerations of business secrets, and individual companies' spheres of influence,

make it difficult to achieve a common sense of direction and complete cooperation in solving these problems. Nevertheless, individual components of the industry have shown essential agreement on several points regarding the need for tuna fishery development. These are:

The need to solve the bait supply problem in terms that will show the feasibility, cost and expected returns on the many alternative methods for getting naturally occurring or substitute bait.

The development and demonstration of purse seine, bait or combination purse seine-baitfishing methods that are successful in the areas of clear water and deep thermoclines.

An evaluation of the fishing activities of foreign interests and the extent of their competitive edge in the western Pacific and Indian Ocean.

A synopsis of data in combination with new work to delineate the times and places of skipjack and other tuna concentrations and migrations.

The development of alternative plans of funding exploratory and gear work.

Further, on the plus side, there are institutional features which favor the tuna industry. Tuna are still under tariff regulation and the balance of payments problem favors the maintenance of a U.S. fleet to catch tuna rather than relying completely on imports. Also, the greater the proportion of the U.S.-caught tuna that is processed, the less dependency there will be on foreign sources for raw material. This is likely to afford some protection from unilateral sections of foreign corporations and governments in controlling price or supply. Therefore, with a larger portion of the U.S. demand supplied by domestic fishermen there is less likelihood of fluctuation in the price of the finished product with U.S. labels. This has important considerations in protecting the U.S. share of the world market.

1.3.5 PIDC

The PIDC, made up of the Governors of Hawaii, American Samoa, Guam, and the High Commissioner of the Trust Territory, was formed in 1970 to coordinate among other programs a Pacific-wide plan to increase the yield from the sea. As a result, in 1972 the Congress of the United States passed Public Law 92-444, authorizing the Department of Commerce to initiate a program to develop the tuna and latent fishery resources of the central, western and South Pacific Ocean. Congress authorized the \$3,000,000 program for a 3-year period; however, no subsequent appropriations have been authorized.

The island regions and elements of the tuna industry have common interests in fishery development, but they also have some quite different objectives. Each would agree that there is a need to establish historical fishing rights in the vast area of the central and western Pacific in order to assure access to the tuna and other high seas fishery resources and a voice in their management. Beyond that, however, the island interests look to the harvest of the resources to contribute to the employment of their people and their overall economic development and the U. S. industry looks to the region for an additional supply of raw material.

As far as the U. S. tuna industry is concerned, the processors are interested in obtaining the additional raw tuna to supply their mainland canneries, plants that they have elsewhere including the two at Pago, Pago, American Samoa, and Honolulu, and others that they may establish in the PIDC area if it proves advantageous to do so. Whereas U. S. processors wish to maintain a viable U. S. tuna fleet (because they otherwise would be entirely dependent on foreign suppliers) they also are interested in expanding their supply sources from wherever else possible including foreign vessels in which they have financial interest or joint ventures which these can arrange. U. S. tuna boat owners, on the other hand, are interested in expanding their area of fishing in order to guarantee year around operation of their vessels. U. S. vessel owners are amenable to the training and employment of crew members from regions other than the U. S. when it is feasible and not contrary to U. S. law. Should U. S. vessels operate from ports of the Trust Territory training and employment of fishermen in that area would be a natural consequence.

Both elements, processors and boat owners, are interested in access to bases in the central and western Pacific for transshipment, cold storage fuel and supplies, live bait, and other needs. Certain of these requirements can be obtained automatically in Hawaii, American Samoa and Guam. The potential for obtaining some or all of these needs in the Trust Territory exists if mutually beneficial and acceptable arrangements can be worked out between the U. S. fishery operators and the authorities in various Districts. Since the Trust Territory is not a part of the U. S. or a U. S. territory, arrangements which are necessary for U. S. fishing activities will necessarily be those which might be made with a foreign country, although it must be emphasized that the U. S. at least at the present time holds a strongly favored status. These arrangements will probably require official negotiations.

The overall plan calls for an expansion of the U. S. tuna industry activities in the central and western Pacific, especially the harvesting segment. If it is successful it will benefit the island areas of PIDC. Just how the benefits may be distributed and what their magnitude might be will depend on many things. They will depend on which fishing methods prove to be feasible, the geographic regions in which adequate catches can be made, where transshipment or processing facilities are available or can be established, where and under what conditions fishing bases can be established and the ability to compete with fishermen of other countries, especially Japan, for the available harvest.

It is not possible to predict which methods of fishing may be successful or which island areas may ultimately benefit. However, some overall assessment of the future can be made. The successful operation of super seiners would be of immediate benefit to Guam, American Samoa, Palau (T.T.) and Hawaii. Guam, which does not now participate in any aspect of the tuna industry, would, because of its location, become an important transshipment point and supply center for the seine fleet. American Samoa with two canneries operating in Pago Pago would benefit from an increased amount of fish for processing. It would also be used as a supply center. The District of Palau with its cold storage facilities would expand its transshipment activities. The existing tuna cannery in Hawaii would receive additional catches for processing or Honolulu would participate in the handling of transshipments.

As far as the bait boat operation is concerned, the most likely area to benefit immediately would appear to be the Trust Territory because of its strategically located islands which blanket a vast area off the western Pacific. Shore bases would be needed for the small vessels which would engage in this type of fishing. Also, they would require access to supplies of live bait, whether natural, artificially reared, or transported from other regions. Evaluation of the feasibility of bait boat fishing, however, is dependent on the cooperation of officials of the Trust Territory, especially those in the Districts and the local communities. They will have to be persuaded that successful exploratory operations are a prerequisite to long-term joint ventures.

Whereas the interest of the U.S. fishing industry may be the development of tuna fisheries in the western Pacific, there is reason to believe that the harvest of the inshore fishery resources could receive favorable attention during the course of developing or expanding a tuna fishery. Both the U.S. fishing industry and NMFS probably could assist jointly in the effort if the High Commissioner's staff and authorities in the Districts considered that it would be beneficial. Success of tuna fishery development activities in the Trust Territory depends on joint planning and a close and continuing working relationship with local people in the several Districts.

Possibly the most difficult problem to overcome from the U.S. point of view will be the conviction on the part of the people of the Trust Territory that the tuna and live bait resources in the waters in their immediate vicinity are far more abundant and available than they really are. There will also be the difficult problem of obtaining the participation of the local population in actual fishing operations.

In summary, the U.S. industry is generally free to undertake whatever development activity it considers advantageous in Hawaii, Guam and American Samoa and whatever proves to be successful will result in some economic benefit to these areas. The situation, however, in the Trust Territory is different in that permission is necessary and certain legal requirements must be met if the U.S. industry is to participate in the development of tuna fisheries of that area. Furthermore, the peoples of the Trust Territory will have to be persuaded and the U.S. industry will have to demonstrate that U.S. activities are of long-term benefit

Finally, those responsible for planning and arranging U. S. tuna fishing activities in the Trust Territory will need to keep abreast of the "Status Discussions" which are underway and which will dictate the entity that the Trust Territory will take in the immediate future. The route which the Territory takes will affect what role the U. S. Government and the U. S. industry can or might take in developing the tuna fisheries of the area.

APPENDIX 2

A SYSTEM FOR DEVELOPMENT OF THE CENTRAL PACIFIC SKIPJACK TUNA RESOURCE

Prepared: July 30, 1968 by B. J. Rothschild, Honolulu Laboratory

1. Synopsis

There is a valuable, underutilized, skipjack tuna resource in the central Pacific. If an economical means of harvesting can be worked out this resource is capable of supporting an industry in Hawaii of a magnitude approaching that of the pineapple, sugar, or tourism industries. Harvesting this resource should not, in principle, be difficult. The use of modern fishing technology will, however, be required. Application of this technology to Hawaii fishing conditions requires the development of a system. The system requires certain information and actions. The information concerns both the resource itself and the economics of the resource. Much of the information is already available. The actions which center around the development of a purse seine technology, that is appropriate for a Hawaii-based fishery, also include operations research on bait fishing development of bait substitutes, studies on skipjack tuna and the environment, and further assessments of skipjack tuna population dynamics. The approximate cost of the entire program is primarily that associated with the purse seine trials, which amounts to \$2,500,000 for a 5-year period. Additional costs amount to \$900,000.

2. The need for a system

The skipjack tuna resource of the central Pacific Ocean can produce hundreds of thousands of tons of skipjack tuna each year. One hundred thousand tons of skipjack tuna has a value of \$25 million to the fishermen, \$62 million to the processor, and \$100 million at the retail level. This resource is therefore of particular interest to the State of Hawaii because it is a virtually unused economic base, which, when utilized, will generate a monetary flow in the State approaching that generated by pineapple, sugar, or tourism.

Efficient utilization of the central Pacific skipjack tuna resource requires development of a fishing technology in which the revenue from fishing must be sufficiently greater than the cost of fishing to the extent that (1) the fishermen make a good living relative to that which they could obtain in a comparable industry, and (2) the boat owners and processors obtain a return on their investment that is favorable when compared to that which they could obtain from alternative investment opportunities.

Development of a technology that is optimal for a Hawaii-based skipjack tuna fleet and attractive to the investor should not, in principle, be difficult since there is already a large store of knowledge concerning (1) the skipjack resource in the central Pacific, (2) bait fishing operations in Hawaii and elsewhere, and (3) purse seine fishing and technology in general. Although the development of an optimal skipjack fishing technology for Hawaii will not, in principle, be difficult, there are pressing problems that need to be solved before such a technology can be realized. These problems result from the large number of variables that must be considered, evaluated, and forged into an optimal technology. Examples of some of the diverse variables are the temporal and spatial distribution of expected catch, the problems associated with purse seine design, cannery construction, characteristics of the labor force, the oceanic environment as it relates to the skipjack tuna, etc. Arriving at an optimal combination of all the various possible variables by an intuitive judgment would be a horrendous task. In order to avoid these intuitive judgments a systematic foundation for considering all of the elements relevant to the development of the skipjack resource in the central Pacific has been constructed. This systematic foundation will provide a prospectus that will guide the development of a maximized profit skipjack tuna industry. The following describes this system in terms of the information and actions required to realize the optimal utilization of the skipjack resource.

3. The information required

A system for guiding the development of a maximized-profit central Pacific skipjack tuna fishery is outlined in figure 1. The system depicted in figure 1 is constructed of an information block and an action block. The elements in the information block are conceptual and spatially arranged whereas the elements in the action block refer to activities and are temporally arranged. The two blocks are linked by feedback so that information resulting from past strategies will sequentially modify and optimize conduct in future actions.

The information block contains two lines of information. One concerns the resource and the other concerns the economic potentials of the resource. In each line the initial operation defines the contemporaneous potentials. Methods of expanding the potentials for the future are then considered. Finally the economic potentials are matched with the resource potentials, enabling a definition of those cost-receipt areas that will be favorable for fishery development. The feasible cost-receipt areas and the information pertaining to these are then assembled and used to formulate the activities that will be conducted for fishery development.

At this point emphasis should be placed on the fact that the information block already contains a considerable amount of information. This information may be synthesized by repeating that there is a substantial, virtually unharvested, skipjack tuna resource in the central Pacific, that this resource has a high unit value and is, in distinction to most other fishery resources, in high demand and technologically available. Furthermore we know that the present method of fishing for skipjack in the central Pacific, with pole and line and live bait is inefficient (when compared to the potential of purse seining).

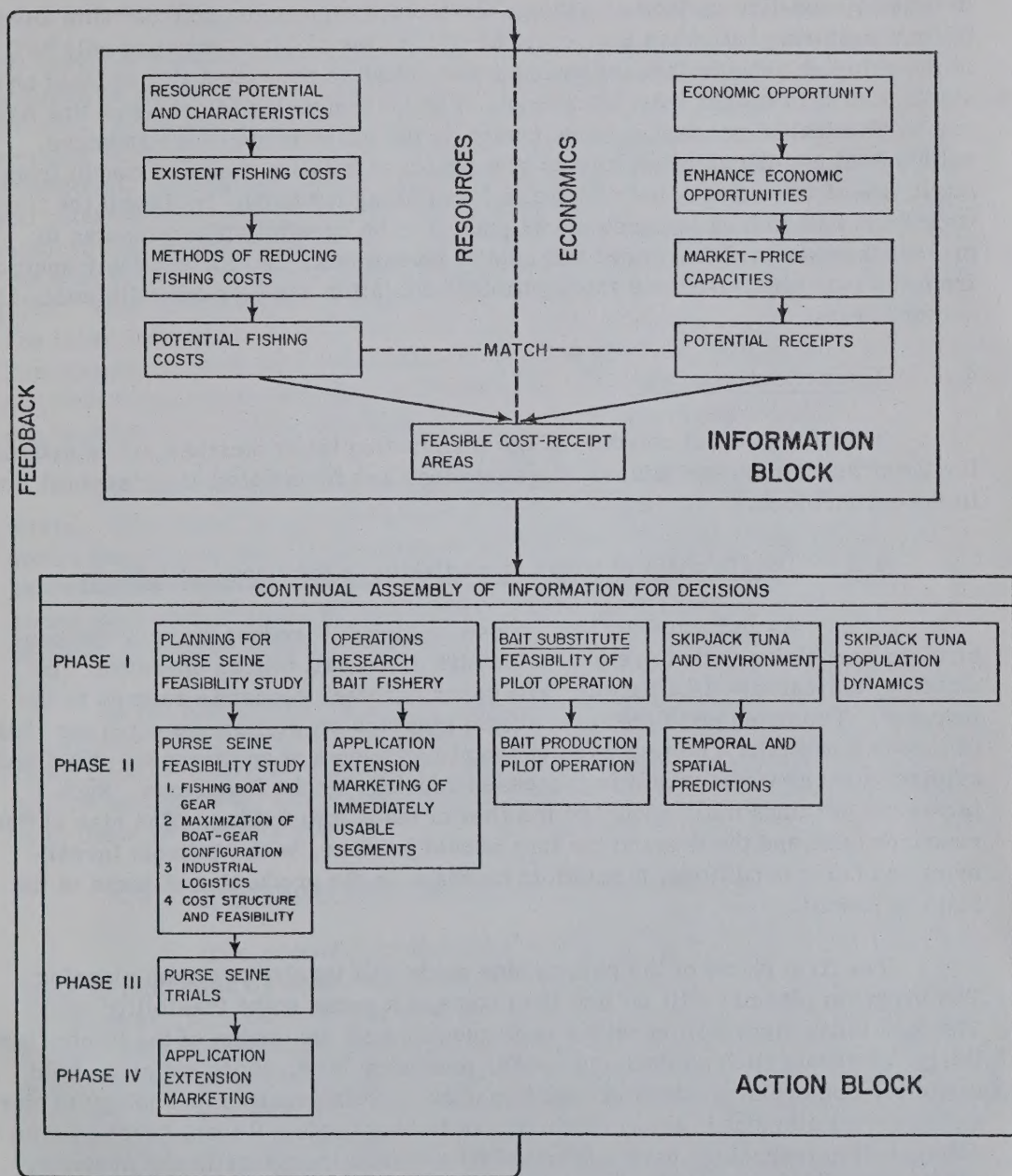


Figure 1.--A system for guiding the development of a central Pacific skipjack tuna fishery.

In the pole-and-line method of fishing, the fishermen spend a considerable amount of time capturing bait when they could be fishing for skipjack tuna and only 50% of the skipjack schools that are encountered "bite" to the extent that at least one skipjack tuna is caught from the school. The inefficiencies of pole-and-line fishing can be eliminated by adopting a gear such as the purse seine which requires neither bait nor the skipjack tuna to bite (in purse seining, fish are caught from about 65% of the schools and no time is lost fishing for bait). In Hawaii the transition from bait fishing to purse seining needs to be carefully planned so as to protect the existing labor force and capital investment. In this way the transition from the less efficient to the more efficient operation can be made with minimal perturbations.

4. The actions required

Thus the present contents of the information block dictate a set of actions for the present and near future. These actions are formulated along several lines in the action block.

4.1 Development of purse seine fishing in the Hawaiian Islands

As indicated earlier, purse seining will reduce many of the constraints on efficiency that are characteristic of the bait fishing operation. In addition, an increase in efficiency will ensure greater economic returns to the investor. The catch per fisherman should increase as well as the catch per dollar of invested capital. The improved economic structure of an increased-efficiency skipjack fishery would result in increased earnings by the fisherman. Such increased earnings will encourage the flow of labor into fishing. The size of the resource base and the demand for tuna should produce, with equitable investment and labor conditions, a manifold increase in the production of tunas in the State of Hawaii.

The first phase of the purse seine study will involve program planning. The program planning will outline the nature of a purse seine feasibility study. The feasibility study will consider such questions as the design of the fishing boat. Design elements such as cruising speed, maximum size, minimum size, hold capacity, and cruising range are all important. Refrigeration technology is also an important element in the construction of fishing boats. Recent developments in refrigeration technology have supported tremendous increases in the monetary return per unit catch for the Japanese tuna fishing fleet. Another consideration in the design of a fishing boat is whether it should be constructed as a single purpose purse seiner or possibly as a combination purse seiner and bait boat, or purse seiner and longline boat. All of these items will be considered in the feasibility study.

Another element that will be considered in the feasibility study is the design of a purse seine and the gear used to set and retrieve the seine. Such features as mesh size, length, depth, and net construction material will be considered. After the engineering concepts of boat and gear design have been developed, methods to maximize the efficiency of any combination of boat and gear will be considered. This consideration will have to take into account the environment and potential catches and is essentially an operations research study in which all features that might affect the potential purse seine fishery will be considered. The next element in the feasibility study would be the best location for a processing plant. This would have to include harbor facilities and boat servicing facilities. The labor force will be considered as well as land availability and tax structures. The feasibility study will conclude with the construction of simulation models that will depict the actual operation of the fishery. The various elements of the model can be adjusted to obtain an optimum economic return to the investor.

The third phase of the purse seine study will be the actual purse seine trials. The actual nature of these trials will be determined by the feasibility study; they will be a pilot operation of the purse seine feasibility study. Pilot operation will test the sensitivity of the feasibility study models and also provide actual demonstrations of the costs and receipts of the increased efficiency of skipjack fishing to potential investors.

In the fourth phase of the purse seine study, extension techniques for the application of purse seining to a Hawaiian fishing operation will be developed. In addition, a continual alertness toward marketing problems and their solution will be maintained. These aspects will most likely be worked on concomitantly with those in the third phase.

4.2 Operations research for bait fishing operations

The second line of study is the operations research on bait fishing. This is motivated by considering that annual landings made by the boat with the greatest skipjack catch are several times that of the boat with the poorest skipjack catch. This large discrepancy must owe to the difference between the way the best boat operates and the poorest boat operates. The objective of operations research is to discover the cause of this difference and to make recommendations toward its elimination. In addition, these studies on bait boats are necessary to clearly define an economic base level from which the purse seining operations can be developed. The operations research on bait fishing will continue in a second phase of extension, marketing, and development of the immediately usable segments of this study.

4.3 Bait substitutes

The third line of study is that of bait substitutes and bait production. This line of action is intended to eliminate the constraint of the necessity for skipjack fishing capital to be involved in bait fishing. This is intended as an essentially short-term action to stimulate the present fishery until purse seining is activated. In addition, there is always likely to be some bait fishing for skipjack for the purpose of landing exceptionally high-quality fish for fresh consumption. The bait studies will also provide information required for operations research study. The economic implications of bait production, bait raising, and bait technology will also be considered in this line of study.

4.4 Skipjack tuna and the environment

The fourth line of study will consider the relation of the skipjack tuna to the environment. These are specialized studies of great importance. Demonstration of a relation between the environment and the temporal and spatial location of the skipjack can measurably increase the efficiency of catching and processing skipjack tuna.

This is because an understanding of such a relation will enable predictions of the temporal and spatial locations of skipjack and thereby eliminate more or less random searching time by the fleet. In addition this information will enable prediction of the temporal distribution of landings and thereby increase the efficiency of a processing operation. The first phase of this work is to determine the relation between the skipjack tuna and the environment. The second phase is to use this information to make temporal and spatial predictions of the distribution of the fish.

4.5 Population dynamics

The last line of study is the population dynamics (i.e., the study of yield potentials of fish stocks) of skipjack. These studies are required to determine the expected catches per unit of area and also to determine basic information for operations research and system study.

5. Costs

At this point only approximate costs can be developed for this study. Approximation is required by the dependence of the terminal phases of the study upon the outcome of feasibility and background studies that will be conducted during the early phases of the study. For example the purse seine feasibility study will determine the best number of boats and the tenure of their operation for the purse seine pilot study. It is likely, however, that one boat would be required for a 5-year period. The cost of this operation would be about \$500,000 a year for a 5-year period, or a total of \$2,500,000. The approximate costs and schedule are outlined in the attached table.